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ORIGINAL ARTICLES.

I.—Geology of the London Extension of the Manchester, Sheffield, and Lincolnshire Railway. Part II: Rugby to Quainton Road, near Aylesbury.[1]

By Horace B. Woodward, F.R.S., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THE cuttings along this new line of railway from Annesley to a little south of Rugby have been described by Mr. Fox-Strangways, and it is now proposed to note the chief geological features along the line as far as Quainton Road, near Aylesbury. This portion of the railway crosses the country from north to south and south-east for a distance of about 35 miles. The following notes were made partly in November, 1895, when the cuttings were examined from Willoughby, near Rugby, to Helmdon; and partly in May of the following year, when the examination was continued to Quainton Road.

Traversing, as this railway does, a hilly country from 200 to nearly 600 feet above sea-level, and encountering over the greater part of the distance heavy clays, a considerable breadth of ground has been occupied, whether by cuttings or embankments. The cuttings have thus exposed a fine series of sections from Lower Lias to Oxford Clay, and also of Glacial Drifts.

Commencing about a mile north of Willoughby, near Braunston, and proceeding southwards, there are three shallow cuttings in the Lower Lias, showing stiff grey marly clay, overlain by fossiliferous clay with hard limestone-nodules. These nodules have assumed fantastic forms, like many chalk-flints, differing in a marked way from the smooth and somewhat ferruginous cement-stones found a little higher in the series. The occurrence of many Belemnites, together with *Gryphæa obliquata*, *Pecten*, *Plicatula spinosa*, and *Rhynchonella*, suggested that here we have equivalents of the strata at Fenny Compton, which long ago yielded so many fossils of the zones of *Ammonites armatus* and *A. Jamesoni* to the late Thomas Beesley, of Banbury. Further observations confirmed this view. The strata dip gently to the south, and the succeeding deposits

[1] The substance of this paper was communicated to the Liverpool Meeting of the British Association in 1896.

comprise clays with ferruginous bands and selenite, and with small flat ferruginous cement-stones. Crossing the Oxford Canal at Wolfhamcote, these clays are found to yield *Ammonites Jamesoni*, *Belemnites*, and *Plicatula spinosa*. At a higher horizon the clays become stiffer and contain ochreous nodules with *Ammonites striatus*; they are equivalent to the beds at one time worked in the Braunston brickyard, where also *A. Valdani* was found. Along this part of the railway the clays were burned for ballast. A cutting about 20 feet deep, east of Nethercote, showed a continuation of these clays, which yield *Inoceramus ventricosus*, *Modiola scalprum*, *Unicardium cardioides*, and some Gasteropods. They evidently belong to the zone of *Ammonites capricornus*, the lower portion of which is sometimes marked as the zone of *A. Henleyi*.

The late Professor A. H. Green, who had previously examined the cuttings from Nethercote to Charwelton, sent to the Museum of Practical Geology a number of fossils which he had obtained from an excavation in the low ground south-east of Nethercote. These were identified by Mr. G. Sharman and Mr. E. T. Newton, as follows :—

Ammonites Maugenesti, D'Orb.
Belemnites.
Avicula inæquivalvis, Sow.
Cardinia concinna, Stutchb.
——— *Listeri*, Sow.
Gryphæa cymbium, Lam.
Lima Hermanni, Voltz.
Ostrea.
Pecten æqualis, Quenst.
——— *æquivalvis*, Sow.
——— *lunularis*, Roem.
Plicatula spinosa, Sow.

The assemblage is interesting as indicative of the zone of *Ammonites Ibex*, which is rarely to be recognized in this country.[1] The fossils come from a position lower stratigraphically than those obtained from the Nethercote cutting.

Proceeding southwards we come to a cutting north of Catesby House, and at the northern entrance to the Catesby tunnel. Here about 12 feet of stiff dark-blue clays, overlain by grey clay with ferruginous septaria, were exposed. Tender pearly and iridescent fossils occur in abundance, and among those obtained by Prof. Green, and (subsequently) by myself, were *Ammonites capricornus*, *A. Loscombei*, *Avicula* (*Monotis*) *inæquivalvis*, *Arca* (*Cucullæa*) *Stricklandi*, *Cypricardia cucullata*, *Hinnites*, *Inoceramus ventricosus*, *Modiola scalprum*, *Pecten lunularis*, *Pleuromya costata*, and *Unicardium cardioides*. Meanwhile, Mr. Beeby Thompson has described in detail the cuttings between Catesby and Woodford,[2] and by his enthusiastic labours he has been able to publish very much fuller lists of fossils from the strata; and especially from the clays just mentioned, which belong to the zone of *Ammonites capricornus*.

The Catesby tunnel is rather more than a mile and a half in length, and is excavated partly in these clays, which are rich in Belemnites, and partly in the overlying laminated micaceous clays and sandy beds of the Middle Lias (zone of *Ammonites margaritatus*). The Marlstone rock-bed (zone of *A. spinatus*) is exposed above the

[1] *A. Ibex* has been recorded from the Kilsby tunnel.
[2] Proc. Geol. Assoc., vol. xiv, pp. 422, 428.

tunnel and at its southern entrance. Much of the material obtained from the tunnel was brought up shafts and tipped along the high ground above the tunnel, and there an admixture of Lower and Middle Lias fossils gave a certain amount of delight and some sorrow to the collector. The same difficulty in separating the fossils from the two zones was experienced at the tunnel near Chipping Norton, where similar strata were excavated, and where very fine examples of *Cypricardia* were obtained. At Catesby the abundant Belemnites occurred in nodular layers with *Ammonites capricornus*; while *A. margaritatus*, *Pecten æquivalvis*, *Gresslya*, and *Cypricardia* were obtained from blocks of grey calcareous sandstone, belonging to the Middle Lias. Mr. Thompson has recorded many other species from the zone of *A. margaritatus*.

A little to the south of Catesby tunnel, and east of Steppington Spinney, a fine section of the Middle Lias was exposed, as follows (see Fig. 1):—

Middle Lias.

Rubbly ferruginous limestone (Marlstone).
Ferruginous sandy clays, about 5 ft.
Blue-hearted calcareous sandstone with serpulæ, much jointed and waterworn, 3 ft. to 4 ft. 6 in.
Yellowish ferruginous clay.

The gentle southerly dip of the strata is modified to the south of this exposure, where the Middle Lias is brought abruptly against the dark-blue clays of the Upper Lias. This fault is regarded by Mr. Beeby Thompson as a reversed one: I saw nothing to indicate that this was the case, and, in fact, noted it as the northern portion of a trough-fault which lets down a mass of Upper Lias clay between two tracts of Middle Lias. The hard rock-bed with serpulæ is of the same character as a band noticed in the Middle Lias in a brickyard at Twyford Lane, near King's Sutton.[1]

It is noteworthy that along the portion of the railway now described, which includes a part of the Lower Lias vale and of the Middle Lias escarpment, no Glacial Drift was exposed. A few quartzite pebbles occur in the soil along the low ground west of Braunston, but these are simply relics of post-Glacial denudation. It seems probable that this tract, like the Marlstone scarp of Edge Hill to the south-west, was not glaciated.

East of Charwelton Hall, at an elevation of about 500 feet, in a tract bordered by somewhat higher ground near the source of the river Cherwell, the Upper Lias clay is overlain by gravel 6 or 8 feet thick. Bordering the stream further south the deposit has been dug to a depth of 20 feet. It is a rudely-bedded sandy gravel, with coarse sand, and pebbles of flint, Chalk, jasper, quartz, quartzite, and ironstone; together with derived Jurassic fossils, notably *Gryphæa cymbium* of the Middle Lias and many Belemnites. It is interesting to find that this deposit was noticed by Conybeare, who remarked: "Near Charwelton there is a small accumulation of chalk flint gravel, and other alluvial débris in the bottom among the hills."[2]

[1] H. B. W., "Lias of England and Wales," p. 225.
[2] "Outlines of the Geology of England and Wales," 1822, p. 248.

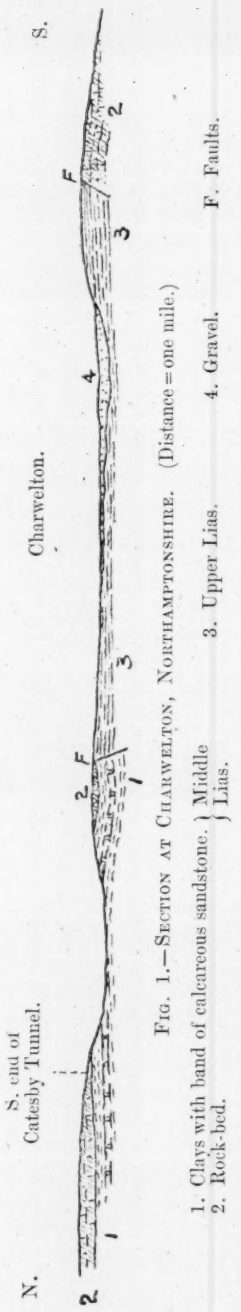


Fig. 1.—Section at Charwelton, Northamptonshire. (Distance = one mile.)

1. Clays with band of calcareous sandstone. } Middle Lias.
2. Rock-bed. }
3. Upper Lias. 4. Gravel. F. Faults.

In the main this must be regarded as belonging to the Glacial Drift, although it may have been rearranged in places by the stream.

Further south, and to the east of Charwelton, the Upper Lias clay with *Ammonites fibulatus* is seen in the cutting faulted against the Marlstone, the newer formation occupying (as before mentioned) the trough, and rubble from the Middle Lias being washed over the clay-slope of the Upper Lias.

South of the river Cherwell, and to the north-east of Charwelton Lodge, there are shallow cuttings in stiff grey and yellow clay (Upper Lias), with a little gravel south of Blindpool Spinney; and near by there are ferruginous, sandy beds, a downwash on to the clay from the "Northampton Sands" of Hinton Hill. The sections here were much obscured at the time of my visit, but my observations accord with those of Mr. Beeby Thompson, who discovered estuarine sands with plant-markings, and attributed the position of the deposit to slips from the higher grounds of Hinton Hill.[1]

To the north of Woodford Halse, a cutting about 15 feet deep showed Upper Lias clay dipping gently towards the south. It contained two bands of ferruginous, earthy limestone, which became thinner towards their outcrop on the north. *Ammonites communis*, *A. bifrons*, and *A. serpentinus* (*falcifer*) occur here. Crossing the East and West Junction Railway to the south of Woodford Halse, we come to a cutting which showed Chalky Boulder-clay (3 or 4 feet) resting on an irregular bed of sand and loam, beneath which was a mass of stiff blue clay, with layers of fine chalk stones—the clay, no doubt, largely derived locally from the Upper Lias. This was the first mass of Glacial Drift encountered along the railway south of Willoughby, if we except the gravel before mentioned.

Further south, to the north-east of Eydon, fine gravel and gravelly loam were seen, resting on blue clay (Upper Lias). By Foxhall Farm, west of Moreton Pinkney, red sand was exposed, and a little further south there was an excavation showing ten feet or more of coarse gravel and sand, with one foot of stony

[1] Proc. Geol. Assoc., vol. xiv, p. 427.

clay or loam on top. The gravel here consisted of flint, quartz, ironstone, Chalk, and Jurassic fossils.

South-west of Moreton Pinkney, the Chalky Boulder-clay covers a considerable tract, and is exposed in the railway-cuttings, resting, on the north, near Foxhall Farm, on blue clay (Upper Lias). At Banbury Lane, in the Barrowhill cutting, the Upper Lias was well exposed to a depth of 30 feet. It comprised stiff blue clay, yellow on top, with cement-stones, and it yielded few fossils except *Ammonites serpentinus* (*falcifer*) and Belemnites. In two cuttings further south, to the north-east and east of Sulgrave, sands and clays belonging to the Estuarine Series beneath the Great Oolite Limestone had been exposed, but the banks had been sloped. The strata were, however, clearly to be seen west of Peter's Farm, north-west of Helmdon, where the following section was noted :—

Chalky Boulder-clay (on the higher ground).

Great Oolite Limestone and Estuarine Beds.	feet.
Sandy marl with *Rhynchonella*	2
Sandy and shelly limestone with *Ostrea Sowerbyi*, *Modiola*, and *Rhynchonella*	4
Sandy and marly clay with *O. Sowerbyi*, *Strophodus*	7
Bluish-black carbonaceous clay, merging into greenish clay	6
Stiff grey and white clay with rootlets and sandy seams	8

The stiff grey clay, which was well shown to the south-west of the Helmdon and Sulgrave road, might furnish a useful tile-earth or potter's clay. The beds overlying the black clay vary much in character, as the oyster-beds become in places solidified into stony layers. The strata beneath the Boulder-clay dip to the SSE., and nearer to Helmdon are overlain by a rubble of Great Oolite Limestone. The stone was worked at one time in quarries to the east of the railway.

South of Helmdon the Great Oolite Limestone was formerly quarried east of Grange Farm. To the south of this there is a cutting in the Great Oolite Series and overlying Chalky Boulder-clay. The strata were as follows :—

Chalky Boulder-clay (25 ft. thick by the bridge north of Glebe Farm).

Great Oolite Limestone and Estuarine Beds.	ft.	in.
Marls and thin clay-bands with *Ostrea Sowerbyi*, and marly limestone with many examples of *Pholadomya deltoidea*; sandy limestone at base	20 to 25	0
Brown sand with lignite and tender shells of *Ostrea*		
Irregular clay-seam	1	8
Brown sand and clay with *Ostrea*		
Dark-grey clay passing down into greenish-grey clay	4 to 5	0
Yellowish clay with rootlets	12	0

I mark no division between the Great Oolite Limestone and Estuarine Beds, as there is no constant horizon by which to define it. The yellowish clay with rootlets is evidently the same as the lowest bed noted in the section north-west of Helmdon; but beneath it, in the foundations for a bridge, nine feet of blue limestone with *Modiola* and *Trigonia* were proved. I was unable to devote time to

collecting from this lower bed, but I am disposed to group it with the Great Oolite Series. The dark-grey and greenish clays are similar to beds which characterize the Upper Estuarine Series, and clays with rootlets, as well as layers with marine fossils, are well known to occur in that division.[1] The representatives of the Inferior Oolite are probably confined to sandy strata (Northampton Sand).

The details of the Public Well at Brackley, kindly communicated by Mr. R. J. Russel, do not help to elucidate the matter, although they serve to indicate the varying character of the beds between the Great Oolite Limestone and the Upper Lias. The well was sunk 60 ft. 6 in. and then bored, and the following strata were penetrated:—

		ft.	in.
	Soil	0	6
Great Oolite Series	Marl	3	0
	Beds of limestone	23	0
	Callous clay	2	0
	Limestone beds and marl	19	0
	Callous clay	2	0
	Rubble limestone	3	0
Northampton Sand	Red sand	3	0
	Black sand	5	0
Upper Lias	Very hard blue clay	101	0
	Stone	2	0
	Blue clay	6	0
Middle Lias	Stone	3	0
	Sand and hard clay	8	0
	Mostly sand	4	0
	Very hard stone	3	0
	Sand and hard clay	6	0
	Very hard stone	5	0
		198	6

Helmdon Stone was formerly held in repute, as, according to Morton,[2] it was used in the mansions of Stowe and Woburn; but for 150 years or more the quarrying of the stone for building-purposes appears to have been abandoned. Some specimens of the stone have been recently sent to the Museum at Jermyn Street by Mr. T. K. Curtis, of Brackley, and they consist of shelly oolitic and earthy limestone, evidently belonging to the Great Oolite. Judging previously by the old records, I had been led to regard the stone as of Inferior Oolite age.[3]

Chalky Boulder-clay was shown in the cutting east of Radstone, and to the south this Drift rests on clayey beds belonging to the Estuarine Series. Crossing the stream, we pass an old quarry where Great Oolite has been worked, and enter the cutting east of Hill Farm, where Boulder-clay five or six feet thick rests on Great Oolite Limestone. In places the Boulder-clay has been weathered into a brown stony loam, but, further on, its grey and chalky character is well seen, and some sections of considerable interest were opened up. Much of the Great Oolite Limestone is a soft, pale, earthy

[1] Judd, "Geol. Rutland," p. 189, etc.; H. B. W., "Lower Oolitic Rocks of England," p. 402.

[2] "Nat. Hist. Northants," 1705, pp. 108, 126.

[3] "Lower Oolitic Rocks of England," p. 475.

limestone resembling Chalk, and here and there it is by no means easy to mark any plane of junction between the Chalky Boulder-clay and the weathered rubble of Great Oolite. At one point there were streaks or strips of reddish-brown clay at the base of the grey Boulder-clay, and more or less parallel to the bedding of the rubbly Oolite below. A little further south the Great Oolite was disturbed and nipped up. Again further south, the Boulder-clay was seen resting on a piped surface of the Great Oolite, the pipes being filled with greenish clay, and with reddish-brown clay precisely like that incorporated in thin strips at the base of the Boulder-clay. (See Fig. 2.)

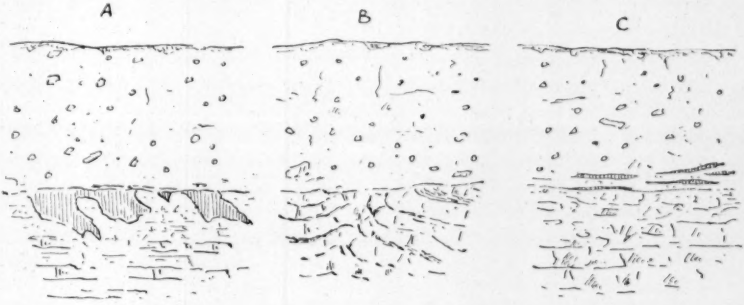


Fig. 2.—Sections East of Hill Farm, Radstone, Northamptonshire.

Chalky Boulder-clay resting on Great Oolite.

(A) Great Oolite with piped surface. (B) Great Oolite disturbed. (C) Strips of brown weathered clay at base of Boulder-clay.

Here evidently the agent which accumulated the Boulder-clay was forced over an old weathered land-surface of the Great Oolite. That formation was disturbed in places, and portions of the old soil were stripped off and included, with masses of the rubbly rock, in the Drift. In other places the Boulder-clay was accumulated evenly on the Oolite, the rubbly surface of which was planed off without producing any marked disturbance in the strata beneath.

At the southern end of this cutting, we pass sections of Boulder-clay with Oxfordian Gryphæas resting on Great Oolite marls, limestones, and *Ostrea*-clays, and then come upon a section of coarse Boulder-gravel and fine sand, exposed to a depth of 12 or 15 feet. The cutting had been partially sloped, and the connection was not very clearly shown between the Boulder-clay and the Gravel; but it was evident that the Boulder-clay abutted against a Gravel mound, the entire cutting (above the Great Oolite) to the north being in Boulder-clay, and to the south being Gravel. It was, moreover, possible to trace a thin course of Gravel underlying the Boulder-clay. The Gravel was rudely bedded, and consisted of Chalk, Oolite, flint, quartzite, and Carboniferous Limestone. Belemnites and the Oxfordian *Gryphæa dilatata* were noteworthy among the derived fossils. Blocks of rock up to a foot in diameter were present. In fact, the assortment of stones in the Gravel was such

as might have been obtained from the Boulder-clay. It may be remarked that similar coarse gravels occur near Buckingham in association with the Boulder-clay, and near the margin of the area over which the ice which accumulated the Chalky Boulder-clay formerly extended.

South-west of Glebe Farm another cutting showed Great Oolite limestones and marls, the stone-beds being poor and rotten, with seams of pale greenish marl. These beds were burned for lime at the old kiln on the west side of the railway. Further on towards Brackley the top beds of Great Oolite are hard, even-bedded shell-limestones, like beds of Forest Marble; while below are banded white, brown, and grey marly beds, and soft marly limestones, 15 feet thick, the strata being locally disturbed by a number of tiny step-faults, the result, perhaps, of land-slipping. Underneath these beds were very fossiliferous, soft, white limestones and marls, with many specimens of *Pholadomya deltoidea*; also *Pecten annulatus*, *Cypricardia*, *Ostrea Sowerbyi*, and other Lamellibranchs; *Natica globosa*, *N. neritoidea*, *Terebratula maxillata*, and *Clypeus*.

Crossing the river Ouse, similar beds of Great Oolite were opened up, some layers of the rock resembling the Helmdon Stone before mentioned. The section in the cutting was as follows:—

	ft.	in.
Rubble and shivered beds of Great Oolite	10	0
Harder bands of limestone, with intermediate marl (2 or 3 feet); many fossils—*Pholadomya*, *Natica*, *Clypeus*, etc. ...	9	0
Banded marly beds and soft white limestone	10	0

The beds change in character somewhat rapidly, as soft, pale, marly limestones develop into harder stone-beds irrespective of clay-cappings. West of Grovehill Farm, a section of Great Oolite similar to that last mentioned was exposed.

It is noteworthy that no Drift occurred along the line of railway in the immediate neighbourhood of Brackley.

Crossing the Banbury branch of the London and North-Western Railway, we enter another cutting in Great Oolite. The uppermost beds were one foot of grey marl and "race," resting on hard shelly limestones (1 ft. 3 in.), like the beds north of Brackley; and the underlying beds were also similar, including grey clays and white fossiliferous oolitic limestones, with *Ostrea* abundant, *Natica*, and other fossils. An irregular bed of gravelly clay and ochreous sandy gravel, 2 to 15 feet thick, rests on the Oolite. Where the gravel is thickest, it has patches of Boulder-clay here and there at the base.

East of Mixbury there is a long shallow cutting in Gravel. At the northern end the Great Oolite, comprising a few feet of hard white limestone weathered into rubble, is overlain by grey clay, and this clay appears to belong to the Oolitic series. It contains a few pebbles, and these have in all probability been derived from the overlying Gravel. In dry weather, when clays become deeply fissured, stones from an overlying Drift or soil may drop into crevices and eventually become imbedded in the mass of the clay, even to a depth of four or five feet, or more. Portions of this long

cutting show only thin gravelly loam four or five feet, or gravelly loam over gravel and sand six feet. By Widmore Farm there is ten or twelve feet of angular gravel and fine gravel and sand. The gravel consists of pebbles of quartz, quartzite, and Oolite, and but few of flint, the flint being mostly subangular. At the south end of Finmere Plantation the Boulder-clay appears from beneath a covering of sand and gravel, with a strong spring issuing at the junction. The relations of these Drifts are thus reversed, but the overlying gravel differs from the Boulder-gravel which elsewhere appeared beneath the Boulder-clay. The Boulder-clay here contains large boulders of Oolite, but these are not noticeable in the gravel. Gravel again occurs over the Boulder-clay at the southern end of the cutting. For some distance by the Barrow near Bartonhill Farm, west of Chetwode, Chalky Boulder-clay was the only formation exposed. South-west of Rosehill Farm it rested on fine buff sand, and a short distance beyond the Oxford Clay appeared.

No evidence of Cornbrash was found in any of the cuttings, the outcrop of this formation being concealed between Newton Purcell and Barton Hartshorn, Finmere and Mixbury, by Drifts.

Onwards by Twyford no sections of interest were exposed: only thin deposits of gravel and gravelly loam were seen on Oxford Clay. In this shallow drift a block of greywether, 2 ft. × 1 ft. 6 in. × 1 ft., was found in the cutting north-east of Charndon Lodge Farm. There 10 or 15 feet of grey shaly Oxford Clay were to be seen. This contained a few pyritized Ammonites, *Cerithium*, *Leda*, and small examples of *Gryphæa dilatata*. The fossils are such as characterize the middle portion of the Oxford Clay. In Decoy Pond Wood the Oxford Clay was opened to a depth of 15 to 20 feet, and yielded medium-sized specimens of *Gryphæa dilatata*. As we approach the brickyard near the Quainton Road Junction, larger forms of this fossil are found, and at the brickyard itself they occur in great abundance. The intermediate shallow cuttings showed no sections of interest, and beyond an occasional thin gravelly soil, as south-east of Leewood Farm, no Drift was observed between Twyford and Quainton Road.

It should be mentioned that on the railway embankment near Steeple Claydon, a large specimen of *Ammonites Sutherlandiæ*, together with *A. Lamberti* in the same block, was picked up, evidently derived from one of the adjacent cuttings in the Oxford Clay. These and other fossils were identified by Mr. G. Sharman and Mr. E. T. Newton.

II.—The Age of the Morte Slate Fossils.

By Henry Hicks, M.D., F.R.S., Pres. Geol. Soc.

In the last number of the Geological Magazine Dr. J. W. Gregory has undertaken to give an opinion on the whole of the fossils described by me from the Morte Slates in the Quarterly Journal of the Geological Society of May, 1896. He says he has been tempted to do this because someone had "recently read to the Geological Society of Cornwall" a paper in which he "assumes the

Silurian age of the Morte Slates to be so well established that it may be accepted as the basis for future work." Clearly this was too much for Dr. Gregory, and his righteous indignation compelled him at once to endeavour to put a stop to any such assumption. I do not, however, think that I shall have much difficulty in showing that Dr. Gregory's facts and conclusions are unreliable, and show a want of care and discrimination. Whether the fossils turned out to be Silurian or Lower Devonian, would have mattered but little in regard to my views of the stratigraphical position of the Morte Slates; for what I maintained from the first was, that the Morte Slates, instead of being newer than the Ilfracombe beds (Middle Devonian), were older than the latter, and that the apparent upward succession was a deceptive one, and had been produced mainly by thrust faults. If, therefore, Lower Devonian beds occurred in the Morte ridge, the evidence would have been quite as satisfactory in support of these views as if they were Silurian or older. The finding of fossils in the Morte Slates only added strength to my view, since every species hitherto found is unlike any which are known to occur in the Ilfracombe beds on the north side and the Pilton beds on the south, and yet there are numerous fossils in common in the Ilfracombe and the Pilton beds. This at once proves that the Morte beds and those surrounding them must belong to very different geological horizons. I may say in passing that I took pains, knowing the imperfect material with which I had to deal, to obtain the opinions of several specialists in regard to the fossils before I ventured to publish the conclusions at which I had arrived. Now the fossil which has been mainly attacked by Dr. Gregory is *Stricklandinia lirata*,[1] and his remarks on the other fossils show that they are principally made to back up his contention with regard to this form. I will, therefore, confine my remarks at present almost entirely to the evidence adduced by him to show that our *S. lirata* is not that fossil, but *Hipparionyx proximus*, Vanux. His remarks are: "If I had to give [Dr. Hicks' fossil] a name, I should, without much hesitation, call it *Hipparionyx* aff. *proximus*, Vanux., and regard it as also closely allied to *Orthis hipparionyx*, Dav. *non* Hall." This fossil was first described in America from the Oriskany Sandstone, and is considered one of its most characteristic fossils. Now the American geologists class the Oriskany Sandstone in the Silurian, but some European geologists place it at the base of the Devonian. In this country the fossil has been found in beds at

[1] In my description of *Stricklandinia lirata*, from the Morte Slates, I stated that it "approaches most closely in its size and ornamentation the specimens in the Society's Museum and in the Jermyn Street Museum, from the lowest beds of Wenlock age at Marloes Bay, Pembrokeshire." Last year I visited Marloes Bay, and collected several other fossils from these beds, and I am more than ever convinced that the fauna is the same as that I have described from the Morte Slates. A figure of *S. lirata* from Marloes Bay is given on plate xxii in the "Silurian System" (1839) as *Spirifer? liratus*, afterwards altered to *Strick. lirata*. After examining the specimen figured in the "Silurian System," I am satisfied that it belongs to the same species as ours. It is important to note this, as it was the first specimen figured, and it is generally recognized as the type-specimen for the genus *Stricklandinia*.

Looe, Cornwall, which are classed as of Lower Devonian age. So far, therefore, as its stratigraphical position is concerned, it would not be at all surprising if we were to find in so great a thickness of beds as is included under the term Morte Slates, a zone characterized by this fossil. In fact, in the second part of my paper I shall be able to show that Lower Devonian fossils do actually occur in the "Morte Slates" of West Somerset, and that they must be as nearly as possible on the horizon of the Looe Beds. Still, the fossils with which we have now to deal must be treated by themselves, and a somewhat careful analysis of the points referred to by Dr. Gregory will be necessary. As preparatory to this I would ask those who are interested in this question to have open before them page 267 of my paper in the Quart. Journ. Geol. Soc., as the figure given there of *S. lirata* is a reproduction from a photograph, and hence cannot deceive anyone, and pl. xxii, fig. 6, "Silurian System"; next pl. xx of Davidson's Monograph of Silurian Brachiopoda; and then pl. xvii of his Monograph of Devonian Brachiopoda, and also the original figure of *H. proximus* in the "Geology of New York," by Lardner Vanuxem, part iii, 1842, p. 124.

I will take the objections in the order given by Dr. Gregory. He says (Geol. Mag., p. 61):—"Dr. Hicks lays most stress on the specimens determined as *Stricklandinia lirata*, Sow., of which he has figured four examples, viz., fig. 3, p. 267; and pl. x, figs. 6, 7, and 8. Of the four specimens, that shown on fig. 8 may be left out of account, as it is a smaller and less satisfactory specimen of the form shown in fig. 6, with which it fully agrees; while that drawn on pl. x, fig. 7 has lost the upper part of the shell, so that its family position is indeterminable; the dotted line on the plate which suggests the position of the hinge-line and beak is hypothetical."

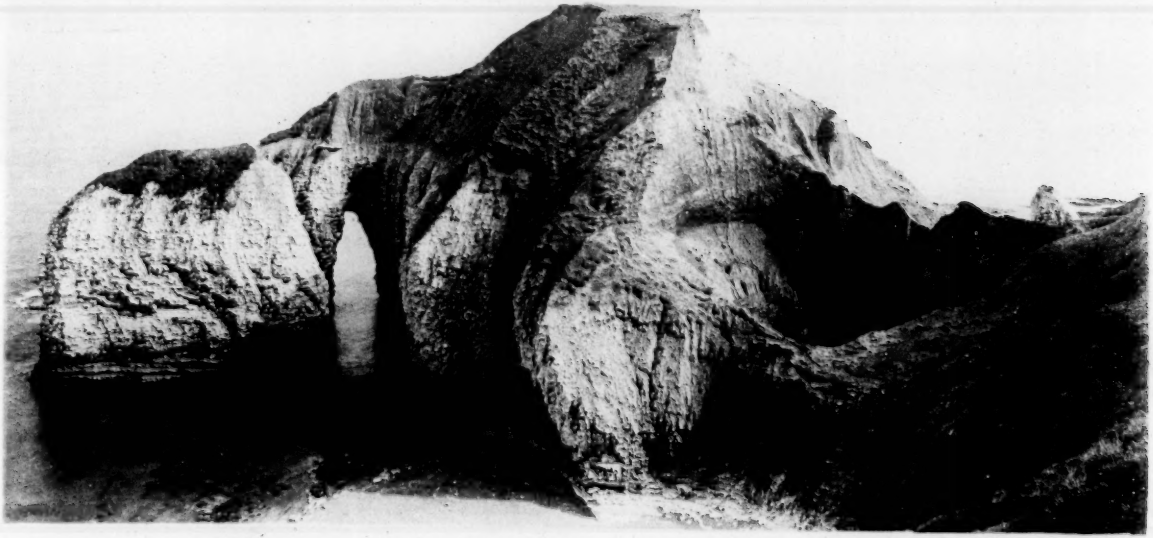
In these remarks not a word is said about the characteristic ribbing, which anyone well acquainted with *S. lirata* would at once recognize as so different from that in *H. proximus*. However, as Dr. Gregory has not recognized this and some other points, I need only touch on those which have caught his eye.

He goes on to say that "the two remaining specimens show three characters. . ." Why call a cast and an impression of the same specimen two specimens? Dr. Gregory is not dependent on the published figures, but says that he examined them with care after the meeting; therefore there is no excuse for his not having recognized that it was but one fossil. However, this error evidently helped to increase his subsequent mistakes, for as fig. 6 is a much broken fragment, its normal size does not become apparent from the figure, and it was mainly because of this that I had the impression fig. 3 given also. We have, therefore, only to deal with one fossil, and fig. 6, instead of being only three inches, should be outlined to over four inches in length. Its width also should be considerably increased, and I am satisfied that, in the normal condition of the fossil, from comparison with other specimens found, it would be still wider than is shown in the impression, as, owing to the strong cleavage-line which exposed the fossil, a portion was left

in the other fragment of the slate. However, for present purposes, we will take fig. 3 as it stands, and take the objections in the order given by Dr. Gregory :—

"1. The hinge-line is recognizable in the specimen shown in fig. 3, although it is not seen in the figure; the hinge-line is straighter than in the genus *Stricklandinia*, and agrees rather with *Orthotetes*." This is a photograph and shows all that is to be seen; what, then, is the meaning of saying that it is not seen in the figure? I can see it clearly, and I presume others can. Davidson says of *S. lirata*, "hinge-line nearly straight, and shorter than the width of the shell," and so it is here. Compare also for this purpose figs. 3, 4, 10, and 11 on pl. xx, "Silurian Brachiopoda." It is well known that the hinge-line in *Orthotetes* is usually *produced*, not rounded at the cardinal extremities. So much for the hinge-line. Next, as to the muscular impressions, we are told "a pair of scars are shown on pl. x, fig. 6, which Dr. Hicks identifies as muscular impressions. If this be correct, it tells strongly against the fossil being a *Stricklandinia*, for the muscular scars are far too large and wide; they agree with those of *Orthotetes*, especially with those of the subgenus *Hipparionyx*." I must once again remind the reader that fig. 6, pl. x is the same fossil as fig. 3, p. 267; therefore the size of the scars is to be compared with the latter figure, and not with fig. 6: and what is the result? The scars reach to less than one-third of the length, and in Davidson's figures (10 and 11) of *S. lirata* they are exactly one-third of the length. In *O. hipparionyx*, on the other hand, as may be seen by examining figs. 8–12 on pl. xvii of Davidson's monograph of Devonian fossils, the scars reach in each case to nearly half of the length of the shell, and in fig. 11 to three-fourths of the length, and in the original figure by Vanuxem they also reach to three-fourths of the length. It is extraordinary that this fact has been so completely overlooked by Dr. Gregory.

Now as to the width of the scars. As their outer margins are only faintly seen, it is necessary to carry the eye forward from the umbo, which in the cast is raised, and the two pear-shaped scars will then be recognized on each side of the raised portion. They are so much flattened that they can with difficulty be defined from the ovarian spaces which surround them, as is commonly the case in crushed specimens of *S. lirata* (see especially the type-specimen in the Geological Society's collection, and figured in the "Silurian System"). The scars, however, occupy less than one-third of the width of the shell, again agreeing fairly with those in fig. 11 on pl. xx of Davidson's monograph. The extraordinary difference to this, shown in the original figure of *H. proximus*, where the scars occupy no less than two-thirds of the width, are strongly raised and joined centrally, and are most strongly defined on their outer margins, will at once strike any observer. These facts are also equally marked in the figures by Davidson of the specimens in the Jermyn Street Museum and elsewhere, obtained from Looé. The shape of the shell also is far more like *S. lirata* than either *Orthotetes* or *O. hipparionyx*. The other fossils to which he specially refers, viz.



High Stacks, Flamborough Head.

To illustrate Mr. W. W. Watts's paper in the January Number, p. 31, on Geological Photographs.

To illustrate Mr. W. W. Watts's paper in the January Number, p. 31, on Geological Photographs.

From a Photograph by Mr. G. Bingley, reprinted by permission from the Proceedings of the Yorkshire Geological and Polytechnic Society 1897.

The Whin Sill at Cullernose, Northumberland.

To illustrate Mr. W. W. Watts's paper in the January Number, p. 31, on Geological Photographs

From a Photograph by Mr. E. J. Garwood, (see County History of Northumberland, Vol. II., Appendix IV).

Pterinea Mortensis and *Modiolopsis Barricanensis*, do not, in any way, bear out the statements in regard to measurements which he gives, if the distortion by cleavage be taken into account. *P. Mortensis* is greatly reduced in length, and increased in width by pressure, so altering the whole shape of the shell and wings. In its normal condition it would agree well with some *Pterineæ* from the Silurian. Some palæontologists have thought that it might be closely allied to *Avicula Danbyi*, a well-known Silurian form (see figs. of *A. Danbyi* in McCoy's "British Palæozoic Fossils"). The distinction between *Modiolopsis* and *Modiomorpha* rests in the dentition, but unfortunately this cannot be seen in any of the specimens hitherto found. None of the statements made by Dr. Gregory can therefore in any way affect the evidence, stratigraphical and palæontological, which I have brought forward to show that the Morte Slates are the oldest rocks in North Devon.

III.—Notes on British Geological Photographs.

By W. W. Watts, M.A., F.G.S.

(*Concluded from the February Number*, p. 62.)

(PLATES III AND IV.)

As promised last month, we now add a brief note on Plates III and IV of this series, given in this number.

Plate III is one of a beautiful set prepared by Mr. Godfrey Bingley for insertion in the Proceedings of the Yorkshire Geological and Polytechnic Society, from which the plate is borrowed by the kind permission of the editor, the Rev. W. L. Carter. A full description by Mr. G. W. Lamplugh will shortly appear in the "Proceedings" of that Society, and from the manuscript of this I have been permitted to extract the following:—

The cliff to the left is the most easterly point of Flamborough Head; it is formed of the lowermost beds of the flintless Upper Chalk, resting on the uppermost beds of the flinty Middle Chalk, which are seen just above sea-level. In the Chalk a steep-sided valley has been eroded which is now filled with drift. One bank of this valley is to be seen in the exact middle of the picture just above sea-level; the rocky bottom of it runs away to the right, and the drifts in it occupy the whole right-hand half of the photograph. First comes chalk rubble, then boulder-clay, next a seam of dark gravel, seen projecting out of the dark shadow thrown by the sharp ridge to the right, then a light gravel with lumps of chalk, and lastly, extending to the relic of the plateau at the top, Upper Boulder-clay. The characteristic weathering of the drift is shown by the ridges and knife-edges, and the great crater or blow-hole which is such a conspicuous feature in the photograph results from the tapping of the old valley by a small cave driven through its wall; this cave is just out of sight in the shadow of the overhanging cliff in the middle of the picture.

Plate IV is taken from a beautiful panoramic view by Mr. E. J. Garwood, and published by him in the "County History of

Northumberland," edited by Mr. Edward Bateson; it has been lent with the kind permission of the present editor. It shows the Whin Sill breaking across the bedding of sandstones and shales which rest on a bed of limestone; on the left of the picture the Whin has caught up and encloses patches of the shale and sandstone, which have been highly metamorphosed; the sandstone is light-coloured in the photograph, and two patches of it, immersed in the Whin Sill to the left, can be distinguished by their light colour and by the deep shadow they throw over the underlying shales; below the further patch to the left the same sandstone and shale are seen *in situ* below the Whin. The photograph was taken at Cullernose Point on the Northumberland coast.

IV.—Note on an "Ovenstone" (Talcose-schist) from near Zinal, Canton Valais.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

In the Val d'Anniviers or Einfisch-thal, which joins the Rhone valley at Sierre, the stoves used in warming the houses are often constructed from a stone obtained in the valley. This is so soft that it can be readily cut into shape, but it resists heat remarkably well. According to Gerlach,[1] it is obtained at two or three places, but the only one which I have examined is a quarry some height up on the left bank of the valley, rather above Zinal, to which I was conducted by my friend Mr. J. Eccles, who had noticed it during a former visit to this part of the Alps. It is a short distance from the path to the Arpitetta Alp, a favourite excursion for tourists. The result of our examination seems to be of sufficient interest to justify a brief notice.[2]

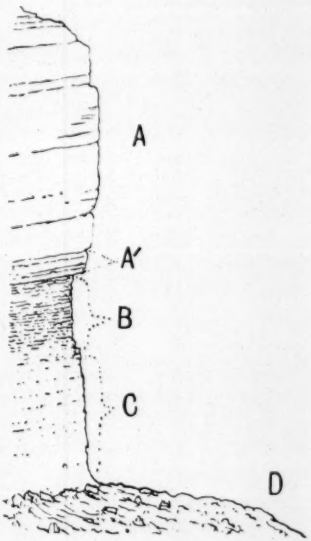
The quarry is a small one, and the outcrop, so far as we could see, is limited. The rock occurs among a group of schists to which I have more than once called attention, as possessing definite characters and having a great extension in the Alps. The dominant rock is a calc-mica-schist, of which every variety may be found, from a marble or dolomite, practically pure, to a calcareous or even quartzose mica-schist, the last sometimes becoming a very typical quartz-schist. Associated with this is a green schist, sometimes fine-grained and slaty in aspect, sometimes coarser and distinctly foliated. It is often very difficult to ascertain the relations of this green schist to the calc-mica-schist. Occasionally it can be proved to be intrusive, and this is often suggested by its mode of occurrence; but positive evidence, so far as my experience goes—and I have devoted some time to the subject—is not easily obtained. On the whole, I think that the rock was originally a basalt or

[1] Beitr. zur Geolog. Karte der Schweiz, Lief. jx, pp. 130–1, 142, 173; e.g. near Evolena, L'Allée, and the Moiry Glacier (in another branch of the Val d'Anniviers).

[2] Gerlach, loc. cit. and Lief. xxvii, pp. 87–90, mentions the connection of this "topfstein" with serpentine, grüner schiefer, and grauer schiefer (the calc-mica-schist), but, if I rightly understand him, is not clear as to its origin, or even that of the serpentine.

dolerite, and is commonly intrusive, generally as a sill, and that it has been converted into a schist by subsequent pressure and mineral change.[1]

The annexed diagram gives the section seen in the quarry. A is a compact variety of the green schist (described below), forming a cliff some five or six yards high, A′ indicating a foot or so at the



base where the rock is more distinctly fissile; B, a soft flaky rock, rather like a crushed serpentine, the thickness, which slightly varies, being from about 3½ feet to 4 feet; C, the "ovenstone," exposed for about 4 feet; D, a spoil bank. Between B and C there is no sharp line of division, the one passing, though somewhat rapidly, into the other. The condition of B made it practically worthless for purposes of study, so I collected specimens from C only, one being slightly more fissile than the other. The dominant tint in each is a lead-grey inclining to a dull lavender, and sometimes, especially on the smooth faces of the more fissile specimen, to a dull green, as in a much crushed serpentine. In both are greenish-white seams more or less parallel with the foliation. The streak also is white, the hardness rather variable, but under 2. Examination with a lens shows numerous glittering granules of iron-oxide rather irregularly distributed, some of the larger being well-developed octahedra, undoubtedly of magnetite. The slice cut from the more fissile specimen exhibits a rather minute wavy, foliated structure, with more definite cleavage cracks running in the same general direction, the dominant mineral varying in tint from a very pale grey to a light brownish grey. It is traversed by rather irregular streaks, like crushed-up veins, occupied by clear

[1] Quart. Journ. Geol. Soc., vol. L (1894), p. 283.

granules and very pale-green streaky or flaky spots. The latter mineral is mica-like and pleochroic, being pale yellow-ochre colour with vibrations perpendicular to the cleavage, and dull green parallel with it. The tints with crossed nicols are low, and extinction is either parallel to or at a very small angle with the cleavage. Probably it is a chlorite. The dominant mineral of the slice occurs in minute flakes closely matted, lying more or less in the same direction, which show high polarization tints, pink and greenish blue dominating. It is difficult, owing to their small size, to determine the extinction angle, but that of a few "frayed-out" scales, rather longer than the rest, was not quite straight, but varied up to about 13°.[1] Still, notwithstanding this, I believe the dominant mineral to be talc.[2] There are a few granules of magnetite. In the slice from the other specimen, though apparently cut in the same general direction, the flakes run slightly larger, are more confusedly matted, and the greener mineral occurs in irregularly distributed patches, which do not suggest any connection with veins; in one case it looks as if these might be pseudomorphic. Magnetite is more abundant, both in granules and crystals, and there is a grain or two of pyrite. A little calcite, obviously secondary, and perhaps slightly dolomitic, occurs in one part of the slice. The differences, however, between the two specimens are only varietal.

I am indebted to Miss E. Aston, B.Sc., for an analysis of the more compact of the two specimens of "ovenstone," described above, which she made in the Chemical Laboratory at University College. It is given below (No. I), and by the side I quote that of a talc-schist from Anglesey,[3] which I now think very possibly has been formed from a serpentine (No. II).

	I.		II.
SiO_2	44·94	... ...	56·34
Al_2O_3	5·47	... ...	8·21
Fe_2O_3	1·75	... ...	3·04
Cr_2O_3	trace	... ...	—
Fe O	3·47	... ...	2·00
Ca O	8·76	... ...	0·52
Mg O	25·57	... ...	25·43
Ni O	2·90	... ...	—
Mn O	trace	... ...	trace
Cu O	,,	... ...	—
CO_2	1·22	... ...	—
H_2O	5·40	... ...	2·86
Id. uncombined ...	0·35	... (Na_2O)	0·79
	99·83		99·19
S. G. ...	2·90	S. G.	2·82

Miss Aston remarked that specimens of the rock (No. I) proved

[1] Cf. description of serpentine from the Gornergrat, Quart. Journ. Geol. Soc., vol. lii (1896), p. 452.

[2] It may be an optical anomaly due to strain, or, as suggested by Rosenbusch, to an admixture with actinolite, almost identical in general aspect. I obtain the results in both slices.

[3] Quart. Journ. Geol. Soc., vol. xxxvii (1881), pp. 44–5.

not to be very uniform, some containing more CO_2 than others. The amount of H_2O and NiO also varied, the latter being in a second sample only 0·5, and in a third not more than 0·25 per cent. The first variation is no doubt due to the fact that the carbonate occurs in small veins. That of the NiO accords with what was observed in the Riffelhorn serpentine, but here I fail to discover awaruite, and conclude that all the nickel must be present as a silicate.[1] So far as one can judge from rough calculations, the specimen analyzed above might consist of quantities, approximately equal, of talc, tremolite, and a chlorite.

Through the kindness of Professor W. Ramsay, F.R.S., I have had the opportunity of examining a specimen of noumeite[2] from New Caledonia, a mineral to which a passing reference was made in the paper by Miss Aston and myself on the Riffelhorn serpentine. The hand-specimen has a somewhat "waxy" aspect and lustre; in colour is a rather variable emerald-green,[3] mottled with spots, diverse in size and quantity, of a dark, somewhat purplish tint, giving the mass a slightly brecciated aspect. This last becomes more distinct on microscopic examination. The apparent fragments are "flaky" in outline, and differ much in size, the larger being darkened by the presence of a brownish dust, but all are more distinctly yellow in colour than the ground-mass. They consist of a fibrous or flake-like mineral, which exhibits a very faint pleochroism and bright polarization tints. The small size and entanglement of the flakes make it difficult to ascertain their extinction angle, but if not straight this angle is very small. Possibly more than one mineral is really present. The ground-mass in which these patches and spots occur is fairly uniform in aspect, just tinged with a greenish yellow, and now and then traversed by lighter-coloured, more compact-looking veins. With crossed nicols it appears as a dark ground speckled with whitish granules or flakelets. Probably, however, it consists of a densely matted mass of doubly refracting minerals, allied to serpentine. The aspect of the whole suggests that fragments of a badly preserved, perhaps rather exceptional serpentine, are imbedded in a kind of steatite. Analyses and a description of noumeite are given in Dana's "Mineralogy,"[4] where it is counted, with garnierite, as varieties of genthite. All three are described as apple-green minerals, varying from light to dark, rather soft, and non-crystalline. Professor Liversidge, who has made special studies of both,[5] states that garnierite differs mainly from noumeite in being much less common, lighter in colour, adhering to the tongue, and falling to pieces in water. Microscopic examination of the above-named

[1] At Ayer, a hamlet about an hour's walk down the valley, are old nickel-mines, but as I did not anticipate this mineral turning up here, I did not visit them.

[2] Named from Noumea, capital of New Caledonia; described by Professor Liversidge, Proc. Roy. Soc. N.S.W. 1875, p. 75; Journal, 1881, p. 227.

[3] This part is not unlike chrysocolla, but the colour is rather brighter.

[4] Ed. 1892.

[5] Proc. Roy. Soc. N.S.W., ut suprà.

specimen makes it fairly certain that the noumeite is in a crypto-crystalline condition, like chalcedony, steatite, etc.[1] Both Dana and La Croix quote a number of analyses, which show that noumeite must be a very variable silicate.[2] Professor Liversidge states that these nickel silicates occur as veins in or incrustations on a brownish or plum-coloured serpentine. There is, therefore, a considerable probability that a nickel mineral of the genthite group may enter into the composition of some of these Alpine serpentines. Generally, no doubt, the amount is small, but I have occasionally noticed a rather peculiar mottling of a rich apple-green material (which now reminds me of the noumeite) and of a purplish one in the Alpine serpentines (recalling the plum-coloured tint just mentioned). Without forming any very definite opinion, I had been disposed to attribute this appearance to pressure, but it now occurs to me that it may be due to the presence of hydrous nickel silicates.

It is well known that serpentine is by no means rare in the Alps. The rock is usually associated with the above-named group of schists, but occurs, though rarely, in the gneisses. Its most common associate is the green-schist. As I have already stated, there are two principal varieties, one containing bastite, the other augite (though sometimes both minerals are present), and the rock is always, or almost always, a dark green in colour. Sometimes the serpentine seems normal in character, but it is often more or less affected by pressure, passing from a stage where it breaks into irregular or lenticular "slickensided" flakes, to that where it is fissile, like a slate. Occasionally we can find distinct evidence that it is an intrusive rock; more often this has to be inferred from the way in which the masses occur, and their outline on a map. The outcrops in the Zinal district are few and small, the largest known to me being on a lofty ridge called the Crête de Million.[3] Here it is clearly intrusive in the green-schist, a mass of which it includes, together with another of a whitish quartzose rock. Some of this serpentine exhibits the effects of pressure, but parts of it have escaped very well. It is the augitic variety. I have examined specimens representing the two extremes of structure. As they differ little from other Alpine serpentines of which accounts have been published,[4] it is needless to enter into minute descriptive details, and I will notice them only so far as they throw light on the "topfstein."

[1] See also La Croix, "Mineralogie de la France et ses Colonies," vol. i, p. 438. He speaks of noumeite as either crypto-crystalline or amorphous.

[2] To speak only of the nickel-oxide, that varies generally from 22·0 to just over 45·0; but in one case 14·6, in another 10·2, and in a third only 2·32. C. A. Münster, quoted in Min. Mag., vol. x, p. 39, says that he has found nickel-oxide replacing magnesia in olivine, serpentine, steatite, etc. Professor Liversidge suggests that the formula of noumeite may be $2\,Mg\,O\,3\,Si\,O_2\,2\,H_2\,O$, where some of the magnesium is replaced by nickel.

[3] I am indebted for notes and specimens of this mass to my friend, Mr. J. Eccles, F.G.S., but I had a remarkably good view of it at a distance of about half a mile, during the ascent of a neighbouring peak. As I know him to be one of the most accurate of observers, and the glen leading to the base of the Crête is very stony and uninteresting, I absolved myself from undertaking a tiresome walk.

[4] By various authors, myself included.

The specimen which shows considerable signs of crushing has a foliated structure somewhat resembling the above described, but rather less conspicuous. It also contains a greenish mineral, which occurs both in irregular streaks and in mottled patches, down to mere specks; this, however, has a weaker pleochroism, but high polarization tints and straight extinction, and is no doubt antigorite. There is some iron-oxide, but the specimen differs little from other crushed Alpine serpentines which I have already described.[1] The specimen of massive aspect is, macroscopically, a dark-green rock, like the last, but is mottled with spots of paler and greyer green. The ground-mass, on microscopic examination, consists of a minute speckled mass of ordinary serpentine, in which flakelets of antigorite occur like an irregular stitching. The lighter spots prove to be a slightly brown augite, often "dusty" in aspect, owing to a minute granular structure. These occasionally enclose grains of serpentine, indicating a slight "lustre-mottling." The edges of the augite are sometimes very slightly frayed out, but there is nothing to connect it with the formation of antigorite. Magnetite is fairly abundant, in grains, occasionally showing some faces of a crystal and in granules, both with a clustered habit. This rock evidently belongs to the group of Alpine serpentines which has been derived from augite-peridotites.[2]

The green-schist, though also affected by pressure, is a very different rock from the "ovenstone." Macroscopic examination alone shows it to be a very characteristic, rather compact member of the green-schist group (Grüner Schiefer). Under the microscope it exhibits a slightly banded, foliated structure. There are two predominant minerals: one is a chlorite, which occurs both in separate flakelets and in streaky aggregated flakes, with pleochroism from pale ochre to dullish green, and oblique extinction, the angle in some cases being quite 25°; the other, which occurs in grains and granules, with rather irregular outlines, suggestive of a clastic (no doubt cataclastic) origin, is water-clear, with rather high polarization tints, one or two grains being twinned apparently on the Carlsbad type. It encloses often minute flakes of chlorite and almost colourless belonites (? actinolite). Probably it is a secondary felspar.[3] A fair amount of calcite is found, and granules of a slightly yellow tinge are rather numerous, especially with the chlorite. I think most of them are epidote, though sphene also may be present. Except for one or two scales of hematite, iron-oxides are absent. That the rock is one of the Alpine "green-schist" group, is beyond all doubt.[4]

A study of this "ovenstone" confirms the view which I have already expressed that a talcose schist may be only a further stage

[1] Some of it shows strain phenomena, indicating the action of a pressure subsequent to that which has produced the general structure of the rock.

[2] Loc. cit., p. 452.

[3] This is the mineral which in some earlier papers I suggested might be a variety of kyanite. It is a frequent constituent of these green-schists.

[4] In these rocks, as I have already described, the green mineral is sometimes a prismatic or acicular hornblende, sometimes chlorite, and both minerals may be present. The "chlorite schist" of the Start and Bolt Head district in South Devon is a rock of similar character to these Alpine green-schists.

in the alteration of a much crushed serpentine, or the third remove, at least, from a peridotite[1]; and the presence of nickel as a silicate suggests that in all probability minerals allied to genthite not unfrequently occur in the Alpine serpentines[2]—and, it may be, in others. Comparison of the ovenstone and of the varieties of serpentine from this and other parts of the Alps with the ordinary green-schist, prove them and it to be such distinct rocks that they must be independent in origin.

V.—*Apiocrinus recubariensis*, Crema, from the Muschelkalk, is a Primitive *Millericrinus*.

By F. A. Bather, M.A.,
Assistant in the British Museum (Natural History).

LAST autumn Dr. Camillo Crema, of Turin, civil engineer, favoured me with a reprint of "Addizioni agli Echinodermi del Muschelkalk di Recoaro," a paper published on October 4, 1896, in Atti del R. Ist. Veneto, ser. 7, vol. vii, pp. 854–61, with plate ii. The Echinoderms described are in the Royal Geological Museum of Turin, and were found in the Lower Muschelkalk near Rovegliana, east of Recoaro, in the Vicentin Alps; a section of the Trias in this district will be found in K. W. von Gümbel's "Geologie von Bayern," Dritte Lieferung, p. 679, 1886. Two species are added, under the names of "*Aspidura italica*, n.sp." and "*Apiocrinus recubariensis*, n.sp." Two crowns of *Dadocrinus gracilis*, though previously known from this horizon and locality, are also figured on account of their good state of preservation.

With regard to the "*Apiocrinus*," Dr. Crema, in his paper, does not "absolutely exclude the chance that it may turn out to be a *Millericrinus*," since the differences between *Apiocrinus* and *Millericrinus* are, in his opinion, of such a nature that they cannot be distinguished in this specimen. "However this may be," the determination assumes importance from the fact that "neither of these two genera has hitherto been observed in terranes anterior to the Lias." Dr. Crema's figure and description, however, did not satisfy me as to the correctness of his generic determination, so that I at once communicated my doubts to him, and asked to be favoured with a cast of the fossil. For reply I received the loan of the unique specimen itself, an act of courtesy for which my warmest thanks are due, not only to Dr. Crema, but to Professor C. F. Parona, Director of the Geological Museum of Turin.

The minute crinoid showed that the description and figure of Dr. Crema were as accurate as the state of the fossil permitted, and that his inferences were very natural ones if nothing more. The additional details now submitted, and the slightly different conclusions of the present paper, have been rendered possible by the further development of the specimen, a task of many days.

[1] Geol. Mag., December, 1890, p. 540.

[2] I do not see much hope of identifying them under the microscope, for the noumeite shows no definite characters.

The specimen (Fig. 1) consists of—

Portion of stem	8·0 mm. long
Cup	2·0 mm. high
Portion of arms	3·0 mm. long
Pinnules extending beyond arms	1·5 mm.
Total absolute length (appearing about 1 mm. less owing to curvature)	14·5 mm.

There is also a portion of an arm, obviously belonging to this specimen, bent downwards along its left side. Other arm-fragments, probably derived from this individual, are scattered over the small slab of stone (5 × 3·5 cm.) on which it lies. This also contains a crenelate columnal, almost certainly belonging to *Dadocrinus gracilis*.

The Cup (Fig. 2) consists of two circlets—basals and radials; doubtless five in each circlet.

Of the Basals three are visible in whole or part. That in the middle, which is clearly seen, is a pentagon, with even horizontal base. Height 1·1 mm.; proportion of height to greatest width almost 3 : 2. The other basals are of similar size and shape, except that their bases appear to slope downwards away from the middle one.

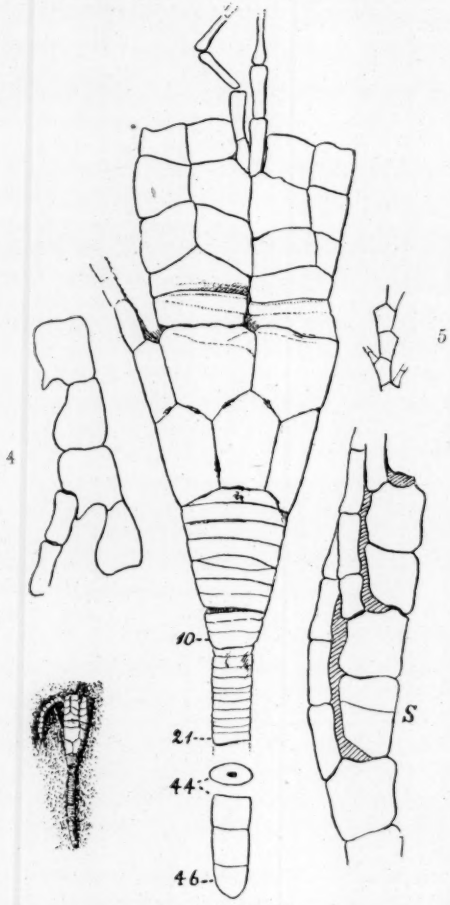
Of the Radials, three are visible in whole or part. That in the middle, which is clearly seen, is a pentagon with the upper angles slightly truncate or rounded, and with the distal margin slightly curved by a narrow median depression and two broader depressions on either side. A distal margin with similar curvature, more emphasized, is figured for *Rhizocrinus Rawsoni*, by P. H. Carpenter ("Challenger Report, Stalked Crinoids," pl. liii, fig. 8). Height about 1·2 mm.; width about 1·3 mm. The curvature necessarily foreshortens the width in the figure. The other radials appear to be of much the same size and shape. This middle radial is peculiar in the presence of a fine furrow running across its upper third and trending downwards from left to right; this may represent an abnormal fission of the radial, for such does occasionally occur, and may in some cases be regarded by a speculative mind as a reversion to the horizontal bisection of certain radials characterizing so many Monocyclic Inadunate Crinoids. The radial to the right exhibits a slight furrow parallel to its distal margin.

The inter-basal and inter-radial sutures are fairly straight; but the basi-radial sutures are a little flexuous, and show appearances of a slight median depression in each.

Portions of three Arms are visible, directly attached to the cup (Fig. 2).

Of these, that on the left consists only of portions of two or three brachials imperfectly seen from the side, and needs mention only because of its position, which suggests, if it does not prove, that during life the arms could be bent outwards from their union with the cup itself, at an angle slightly exceeding the slope of the sides of the cup. The proximal brachials of the middle and left-hand arms are, on the contrary, bent inwards, so as to lie at as great an

angle in the other direction. These facts, therefore, indicate that the union between radials and first primibrachs was a true articulation, permitting motion through an angle of at least 45°. The sinuous distal margin of the radial also suggests that the union was articular, and certainly not by close suture.



Millericrinus recubariensis, Crema, sp.

Fig. 1. The type-specimen, × 2.
,, 2. The cup, arms, and portions of stem of the same, × 10. The proximal surface of the 44th columnal is drawn.
,, 3. Portion of an arm-fragment lying near the lower edge of the slab on which is the type-specimen, × 12. *s* = syzygy.
,, 4. Portion of the arm-fragment that is bent downward on the left side of the type-specimen and probably belongs to it, × 12. This is drawn with the distal end downwards, as in Fig. 1.
,, 5. Portion of fragment from the distal end of an arm, × 12.

A further point of importance in this connection is the separation of the arms from one another by a space beginning, as above intimated, on the shoulders of the radials; while the absence of preserved inter-brachial plates in this space suggests that it was filled, if at all, only by a flexible extension of the tegmen, in which such plates as may have existed can only have been minute and loosely united. In short, there was nothing to impede the perfectly free movement of the arms which we have already inferred.

The Primibrachs (IBr) are two. Their width is slightly less than that of the radial, but they expand a little upwards. IBr_1 has a height of little less than half its own width. Conspicuous on IBr_1 of the middle arm is a clear, fine groove slanting downwards from the left upper angle to a little below the middle of the right side. A somewhat similar marking is less evident on IBr_1 of the arm on the right. This line may indicate the compound origin of IBr_1, and may even be caused by a syzygial suture, such as occurs at the same level in *Calamocrinus Diomedeæ*; but it is hardly definite enough to permit one to speak of three primibrachs. Each IBr_1 further shows a faint groove close to, and parallel with, its distal margin, IBr_2, the axillare (IAx), is about ·75 mm. high and 1·4 mm. wide. In the middle and right-hand arms it lies at an angle to IBr_1, forcibly suggesting that here also the union was articular.

Of the Secundibrachs (IIBr), three are preserved in each distichal series of the middle and right-hand arms. $IIBr_1$ and $IIBr_2$ are subquadrate, about as high as wide, expanding upwards slightly. $IIBr_1$ bears no pinnule. In the right-hand branch of the middle arm and the left-hand branch of the right-hand arm, $IIBr_2$ bears a pinnule at its outer upper corner. This was probably also the case with $IIBr_2$ in the other branches. $IIBr_3$ is narrower than the preceding, and seems to have borne no pinnule, but was most probably joined to $IIBr_4$ by a syzygy—a fact that would explain the snapping off of all the branches at this level.

On the suture between $IIBr_2$ and $IIBr_3$ in the left-hand branch of the right-hand arm, is seen a small upward bend, which represents the end of the fulcral ridge, and indicates that, as one would expect, this union was a perfect articulation.

The first Pinnules (Fig. 2), like those in more distal regions of the arm (Figs. 3 and 4), are thin, and composed of ossicles with a length three or four times their own width, and with slightly hollowed sides. Similar pinnules are possessed by the adult *Antedon longipinna*, but seem to be common to all young Antedons, and perhaps to the young of most pinnulate crinoids.

There is no proof, nor is it at all probable, that the arms branched again. We may therefore consider the adjacent arm-fragment (Fig. 1), and the other fragments alluded to, as composed of secundibrachs, and may describe them here.

The adjacent arm-fragment (Fig. 1) consists of ten brachials, disposed in a curve with a chord of 3·25 mm. Five of these seem to show traces of pinnules, and the alternating five doubtless bore

pinnules on the other side, so that in this portion of the arm there were no syzygies. If we assume, as seems legitimate, that this arm-fragment represents the immediate continuation of the left-hand branch of the middle arm, then the pinnules of this arm will have followed in regular alternation on all IIBr down to $IIBr_{13}$, except the first and third. A portion of this arm-fragment is enlarged in Fig. 4. It shows clearly the origin of the pinnules, and the spine-like process, presumably the end of a narrow ridge separating the pinnule-facet from an embayed curve just ventrad of the distal margin of the brachial. Such an appearance is not exhibited by recent specimens of *Calamocrinus*, *Pentacrinus*, or *Metacrinus*, but is fairly common in ten-armed species of *Antedon*, especially *A. longipinna*, *A. hirsuta*, *A. lævis*, of the *Tenella*-group; also in *A. echinata*, of the *Basicurva*-group. It occurs, as here, neither in the immediately proximal, nor in the more distal, regions of the arm, but is most obvious in the second quarter of the distichal series, or thereabouts.

A more distal portion of an arm, lying separate on the slab, and probably from about the third quarter of the arm, is represented in Fig. 3. Here the ridge bounding the pinnule-facet is no longer perceptible, while the embayed curve can hardly be distinguished from the general curve of the distal articular surface. Two of the brachials here shown are united by a syzygy (*s*), and form a syzygial pair with a total length very slightly more than that of an ordinary brachial from the same region.

A small fragment, most probably belonging to the distal region of an arm of this specimen, is depicted in Fig. 5. In this the brachials, as usual in distal arm-tracts, have almost the aspect of axillaries, though each pinnule, rapidly becoming more thin than the main arm-branch, is easily distinguished from it.

Of the Stem (Figs. 1 and 2), 46 columnals are preserved. As seen in the normal position of the specimen, they are of rounded appearance, with neither angles nor depressions, nor any trace of cirri or cirrus-facets. The proximal 10 columnals gradually increase in width towards the cup, forming a cone, the sides of which are continuous with those of the cup, the angle being, as Dr. Crema says, about 20°. Immediately below the cone the columnals appear compressed, so that the stem seems constricted to ·25 mm.; but they immediately resume the normal width of about ·5 mm., which continues to the distal end of the preserved fragment.

The proximal columnal is thus described by Dr. Crema: "La placca centro-dorsale, relativamente sottile, pressenta ben sviluppate le cinque creste salienti." By "placca centro-dorsale" Dr. Crema means, as so many palæontologists erroneously mean, the columnal which De Loriol has named "article basal." This phrase denotes nothing more than a proximal columnal, permanent in size and position, often larger than the succeeding columnals, and usually marked on its proximal surface by five depressions for the five basals, between which are five distinct ridges. In ascribing such a columnal to the present specimen, Dr. Crema must have jumped too rashly from a part to the whole. It was, and even now

remains, impossible for anyone to see "le cinque creste salienti," even if they existed. But they do not exist: the proximal columnal is now shown to be incomplete; it only occupies a portion of the basal surface of the cup, and some of the basals rest, in whole or part, on the columnal next following.

Between the fourth and fifth columnals is an intercalated ossicle, which may be a fresh columnal in the early stages of development. It appears, however, as though growth of the stem, by the intercalation of columnals, was effected chiefly below the level of the cone; the 15th and 20th columnals of this stem are such freshly formed ossicles.

In the cone and proximal region of the stem, all the columnals are relatively low; but towards the distal end of the portion preserved they increase in height, so that the 45th is rather higher than wide.

The columnals are stated by Dr. Crema to be "coperti nelle faccie articolari da fine strie raggiate." What articular surface was seen by Dr. Crema I cannot make out from the specimen; nor does it appear to me that the suture-lines, as seen in the normal position of the specimen, yield any evidence for the presence of radiating striæ. As a matter of fact the only articular surface that I was able to expose, namely the proximal surface of the 44th columnal (see Fig. 2), appeared under the microscope perfectly smooth. It should further be noted that it was elliptical in section, perhaps owing to compression after death, so that the actual diameter of the stem would have been about ·37 mm., instead of ·5 as it appears.

The 46th columnal, the last preserved, is rounded at its distal end. This may be due to the weathering of the fossil, or may indicate that the animal freed itself from its attachment while living, as in the classical instance of *Millericrinus Pratti*, so well described by P. H. Carpenter (Quart. Journ. Geol. Soc., vol. xxxviii, p. 29, Feb. 1882).

We have now to consider to what genus this crinoid belongs.

The genera as yet recorded from the Muschelkalk, and indeed from the Trias generally, are *Encrinus*, *Holocrinus*, *Dadocrinus*, and some columnals doubtfully referred to *Pentacrinus*. The fragments to which other names have been assigned by various authors are probably all to be referred to one or other of these genera, except when they are not crinoids at all. Examination of the type-specimen (Brit. Mus. 75,861) of *Flabellocrinus cassianus*, Klipstein ("Beitr. z. geol. Kenntniss d. östl. Alpen," p. 277; 1845), proves it to be an *Encrinus* not far removed from *E. cassianus*, Laube (1865). *Traumatocrinus*, Wöhrmann ("Die Fauna d. sog. Cardita- und Raibler-Schichten, u.s.w.," Jahrb. geol. Reichsanst. Wien, xxxix, p. 190; 1889), which has for type *Porocrinus caudex*, Dittmar ("Zur Fauna d. Hallstädter Kalke, u.s.w.," Geognost.-palaeont. Beitr. I, Heft ii*b*, p. 394; 1866: non *Porocrinus*, E. Billings), is based only on columnals which do not differ greatly from some of *Encrinus*. I am indebted to Dr. Emil Böse, in Carlsruhe, for the references to this

little-known form, which, in any case, has nothing to do with the present species. From *Encrinus* this differs in its uniserial arms, its narrow conical calyx, and minor characters. From *Holocrinus* and *Pentacrinus* it differs, if in nothing else, in the total absence of cirri. It might be regarded as a young *Dadocrinus* were it not for the absence of all expansion in the radial circlet, the conical enlargement of the proximal columnals, and perhaps the tenuity of the pinnules, especially the proximal one, which in *Dadocrinus* is relatively large, retaining more than the other pinnules a memory of the time when it was a full-grown arm-branch. The position of brachial syzygies, however, accords fairly with what we know of *Dadocrinus*, except for their occasional occurrence in the more distal regions of the arm.

Turning to pre-Triassic Inadunate crinoids, there is no reason to suppose that they contain a congener of our fossil: the apparent regularity of the cup, the absence of any anal plates or anal tube (inferred from the space occupied by the radials in the portion exposed and from the absence of any remains of an anal extension of the tegmen), and the non-appearance of infrabasals, all disincline one to place it with the Palæozoic Inadunata.

We look, therefore, to the Mesozoic crinoids, and among them we must, I think, confine ourselves to the pseudo-monocyclic descendants of the Inadunata. There is no reason for instituting a comparison with such totally different forms as *Bourgueticrinus*, *Rhizocrinus*, *Eugeniacrinus*, or their allies. From the Pentacrinidæ this crinoid is removed by the absence of cirri, and we are thus restricted to the Apiocrinidæ.

The family Apiocrinidæ is that to which Dr. Crema has referred his new species, but his reference of it to *Apiocrinus* is opposed by the details now manifest. It is clear, as shown above, that the primibrachs of each ray were not united by close suture either to the radials, or to each other, or to the primibrachs of the adjacent rays; but these are, as Dr. Crema fully recognizes, the chief characters distinguishing *Apiocrinus* and *Guettardicrinus* from *Millericrinus*. Not that this species is a very typical *Millericrinus* either. The proximal cone of the stem undoubtedly suggests the Apiocrinidæ, but the proximal columnal itself has neither the full development nor the regular shape, with "five salient crests," that would entitle it to De Loriol's name, "article basal." It is true that the proximal columnal of Apiocrinidæ may abnormally be imperfect, as in *Millericrinus Pratti* (see P. H. Carpenter, Quart. Journ. Geol. Soc., vol. xxxviii, p. 33); but that does not make the present structure any evidence in favour of Apiocrinid affinities. The columnals below the cone are, as a rule, in Apiocrinidæ of less height than those of the cone; but here they are higher. The basals are higher in proportion to their own width, and to the height of the radials, than they are in any *Millericrinus* earlier than the globose and peculiar species of the Sequanian, such as *M. fleuriausianus*. In fact, the height of the radials also, and the height of the cup generally, are not quite in keeping with *Millericrinus*, which, like all Apiocrinidæ,

usually has the plates of its cup wider than high. According to De Loriol ("Paleontologie Française, Terrain Jurassique, Crinoides," p. 319), the first and second primibrachs of *Millericrinus* are united by synostosis; here the evidence seems to point to a more flexible union. Moreover, one may adduce the apparent compound nature of $1Br_1$ as a condition that has never been found in any Apiocrinid, except the very different *Calamocrinus* of modern times. The secundibrachs too, with their delicate pinnules, have not the wide and thickset appearance so characteristic of nearly all Apiocrinid arms known to us.

It must, of course, be remembered that some of these features are those of youth: such especially are the relatively large basals and the fine pinnules. Nevertheless, all cannot be thus explained away, and it must be admitted that the species is distinct, not only from other known species of *Millericrinus*, but from the general type of the genus and of the family Apiocrinidæ. Indeed, apart from the proximal cone of the stem, perhaps even with that encumbrance, there seems small reason why this form might not just as well be placed along with *Dadocrinus*, either in the Encrinidæ, where *Dadocrinus* is placed at present, or in some fresh systematic pigeon-hole.

The facts, then, seem to lead us to the conclusion that the *Apiocrinus recubariensis* of Crema is a form intermediate between the Encrinidæ and Apiocrinidæ. Its nearest allies are, on the one hand, the Encrinid that other considerations have already brought us to regard as near the ancestor of both Pentacrinidæ and Apiocrinidæ, as shown in my paper "*Uintacrinus*: a Morphological Study" (Proc. Zool. Soc. 1895–6, pp. 974–1004), namely *Dadocrinus*; on the other hand, the genus that is clearly the least specialized Apiocrinid, namely *Millericrinus*. Considering the obviously immature characters of the specimen before us, it would be unwise to make it bear the weight of a distinct generic name. I shall therefore, somewhat arbitrarily, consider the proximal cone of its stem as entitling it to association with *Millericrinus* rather than with *Dadocrinus*, and so leave with Dr. Crema the honour of having been the first to make known the presence of an Apiocrinid in strata below the Lias, and of a complete *Millericrinus* in beds older than the Inferior Oolite.

It will now, I hope, be understood that *Millericrinus recubariensis* is a form of singular interest, and that others besides myself may be grateful to Dr. Crema and Professor Parona for having sent it over land and sea to be described and figured in greater detail.

VI.—On the Erratic Boulders and Foreign Stones in the Drift Deposits of Eastern England, and their Lessons.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

HAVING already discussed the contents, the distribution, and general facies of the widely-spread deposits of Eastern England, which together make up the series classed as Glacial beds, namely, the Post-Tertiary clays, sands, and gravels which have been supposed to attest an Ice period; and also set out the reasons why, to

myself and perhaps to others, the attribution of the surface-beds to such an origin is irrational and impossible (irrational because the theory involves our overlooking nearly every feature of these beds in order that we may explain one or two difficulties in them; and impossible because, so far as ice can be judged by the tests of ordinary mechanics, it is incapable of performing the kind of work which has been demanded of it by those who explain these beds by the intervention of ice in any form)—I will now turn to one element in the beds which still remains to be examined, namely, the foreign stones. These, as I have said before, constitute barely a hundredth part of the whole, and yet they have dominated the position so much that it is chiefly on their account that geology has been burdened with perhaps the most stupendous appeal to the imagination which it has had to carry in its long career.

Before I turn to the special features which mark these foreign stones, I will say something of certain characteristics which they share with all the boulders and masses of stone in these beds, and which seem to put an appeal to ice for their explanation out of court.

If I traverse in part some elementary ground, it is because elementary mechanics are so constantly ignored by the Glacialists. By ice I mean, of course, what every-day people mean by ice—the ice we can examine in our laboratories, or in glaciers, or in those sheets which occupy some upland districts of Switzerland, Norway, or Greenland. I do not mean the ice that exists in Mars or in Saturn, or in the imagination of that transcendental school of philosophers who call themselves Glacial Geologists. About this latter kind of ice I know nothing, and I profess to know nothing. Nay, more, when I am gravely told that the ice in the ice-sheets of former days was something so different to the ice we can experiment upon, that it is no use appealing to the latter (which is the last ditch in which the Glacialist plants himself), I feel that the question at that stage has become one of poetry, and that the Poet Laureate, and not a simple reader of the Geological Magazine, must be the judge. The ice I propose to discuss is perfectly mundane—is frozen water and nothing more.

A glacier, such as we know it, is a mass of ice which moves to some extent *en masse*, so long as its bed has a sufficient slope to give it impetus, but in the main moves as a plastic body by the rolling of one of its layers over another.

When there are overhanging or projecting rocks above its surface, these get disintegrated by the action of frost and weather, and the result is that angular masses of varying size roll down upon the back of the glacier. If the slope of the glacier's bed be slight and continuous, the glacier will be a continuous river of ice, without cracks and crevasses, and these angular stones will be carried by the glacier on its back as far as the ice continues to move, retaining their angularity throughout, and remaining angular at the finish.

If the slope of the bed of the glacier be neither continuous nor even, but be in some places at a sharp angle and in others at an

obtuse one, or be marked by hummocks, the strain upon the ice at certain points will cause it to crack and gape and to form crevasses. These crevasses will remain open so long as the strain exists, but when the glacier gets on to even ground they will necessarily close up again. We cannot understand how crevasses can be formed, or remain open long, where ice is moving over a level or nearly level surface.

The result of the formation of these crevasses if the ice be not very thick is that some of the stones which have fallen on the glacier's back will tumble down fissures and reach the glacier's bed. The rest which escape this and similar catastrophes will continue their journey, as before, to the glacier's foot. This process has been often observed, and is, of course, an elementary experience in the Alps. It is usually argued by those who believe in ice-sheets several miles high that exactly the same process would take place with them. How this is to be brought about I fail to see. A great hummock or lump in a glacier's bed may cause a sufficient strain to crack and open out a crevasse in ice two or three hundred yards thick; but what possible lump or hummock is to cause sufficient tension in a mass of ice even a mile thick so as to cause it to crack and gape, is beyond my prosaic mind to conceive. This stupendous mechanical difficulty is not met at all by the Glacialists, but is quite ignored by them.

The fact is, that even in the Alps, where the ice is thick, a great many of the crevasses do not reach the bottom of the glaciers at all, and the stones which fall into them are arrested midway, forming the so-called englacial boulders about which so much astonishing matter has been written, and to which I shall revert presently. What I now wish to emphasize is, that where no rocks project above the surface of the ice the glacier will carry no stones. This is beautifully proved by the case of Greenland. In those parts of Greenland where there are no *Nunatakkar*, the Danish observers have noticed that there are no moraines, and it would seem to follow that when, as is postulated by the extreme Glacialists, the whole of a country was buried deep in ice and there were no projecting rocks above its surface, there could be no boulders on its back.

I cannot conceive how it is possible to understand (as a mere piece of mechanics) how crevasses could be formed at all in those stupendous ice-sheets which are continually postulated, and how, therefore, any stones could under any circumstances reach the ice-back or the ice-bed in such cases. The ice-sheets would be as barren of stones as the glaciers of Central Greenland are of moraines. Let that pass, however.

Following in the footsteps of my friend, Mr. Oldham, I have tried to show in my "Glacial Nightmare" that ice cannot be moved *en masse* along a level surface by any push from behind it for more than about seven miles without crushing, and in order to move it in this way the thrust must be enormous when the ice is at all thick—so enormous that I have never been able to understand how and by what process the thrust can be transmitted along the mass when

once we leave the steep mountain valleys where glaciers are generated. Of course, to the people who deal with the kind of ice that Alice found in Wonderland everything is possible, and nothing needs proving; but to most of us it is a condition precedent to our assent to the postulate that an ice-sheet several miles thick can be moved *en masse* along a level surface, that some sufficiently potent impetus should be pointed out.

The second way in which ice can move is by virtue of its plastic nature. This I have discussed at great length in my work already cited. There can be no doubt, as is shown by evidence of all kinds, that the principal movement of a glacier is of this kind. There can be just as little doubt that this movement must be slow under any circumstances, and in a body so little plastic as ice that it requires a very considerable slope in the surface of the glacier to initiate it. Thirdly—and this is most important—this kind of movement is largely confined to the surface layers of the glacier, and, except on very steep slopes, there is hardly any movement at all in the lower layers. Ice, in fact, acts very much as water does in regard to this mode of motion, and I believe myself that on a level bed, whatever the slope of the upper surface of the ice, there is virtually no motion at all in the lowest layers. This view, I know, is shared by most physicists, and it is quite preposterous in the great mass of Glacial geologists to habitually ignore the stubborn fact in their iterated statements. The burden of proof lies upon them. Before a postulate is admissible in science at all, its reasonableness and its accordance with the ordinary laws of nature ought to be made out, and until they be made out the theory can have no permanent place in science; and this is at present the position of the theory of ice-sheets moving over hundreds of miles of level surface, as continually postulated. It is, in effect, an appeal to the reversal of the laws of nature.

Let us grant, however, that the orthodox geologists are right, and that on *a priori* grounds even, they have a serious case; and let us go on to examine some of the concrete facts that have to be explained under any circumstances. First, what is the kind of treatment which stones entrapped between a glacier and its bed are likely to receive? There is a school of geologists who argue as if it were possible, or even conceivable, that a great mass of almost solid ice, pressing down with the pressure of many tons to the square foot, can in some way disintegrate its own bed and drag up fragments of stone out of it, as a carpenter takes old nails out of a box. Then Mr. Carvill Lewis speaks of "a deposit composed of fragments torn by the glacier from the basement rock over which it passes." How this extraordinary proceeding is to be done I know not, nor have I ever seen any attempted explanation of it, and until some explanation of some kind is forthcoming I shall continue to treat it as an impossibility. Another set of geologists urge that, in some way or other, stones can travel upwards through glacier ice, and so rise from its base to its surface. Here, again, the whole proceeding seems incredible to anyone who analyzes what a moving viscous body really does with

the solid materials it comes across, and what it would have to do to overcome gravity in this way.

It is quite true that stones sometimes occur imbedded in the mass of a glacier, and afterwards appear at its surface, and thus superficially seem as if they had travelled upwards; but this is due to a very different process. If a stone falls down a crevasse, and is arrested before it reaches the floor of the glacier, it will, when the crevasse closes up on level ground, be imbedded in the ice. If, again, a stone or a group of stones lie on the back of a glacier, and a succession of snowfalls come upon it, which snow is converted into ice subsequently, it or they will become imbedded in solid ice, and in this way so-called englacial drift may be formed. When by ablation or by the direct rays of the sun a certain quantity of the surface of the glacier is subsequently removed, these imbedded stones will appear, like the imbedded remains of the famous Austrian travellers lost three centuries before they appeared on the surface of the Glacier of Thisdul in 1885; but this is not by any process of travelling upwards through the ice from its bed to its surface, for which no mechanical explanation seems in any way available, but by the uncovering of what was always in mid-ice. What is true of travelling upwards is equally true of travelling downwards, or perhaps more true, for it involves the stones travelling from less to more dense strata of ice, and from layers under slight pressure, and therefore friction, to layers under great pressure and great friction. The stones will, in fact, move with the layers in which they are imbedded, and when a glacier is moving on *a rapid slope*, as Spencer noticed by going underneath such a glacier in Norway, the scattered stones, *even at its base, will be slowly moved*—very slowly, since he noticed that the ice itself, which at this level crept very quietly, and the layers above, were apt to move over the stones and to have gashes cut into themselves by them. *This was on a steep slope.* On level ground, as I have said, the capacity of the nether layers of any ice mass which we can conceive of, for any appreciable motion or for exercising any appreciable thrust upon the stones beneath it, is most doubtful.

But let us pass on, and suppose it had the capacity. What must happen? A stone falls to the bottom of a crevasse. The ice begins to move, and the stone is rapidly enveloped in ice, and is held in its grasp as in a vice. As the ice moves on and exercises a certain thrust upon the stone, it will act like the slipper or skid of a coach, and its lower surface in contact with the glacier's bed will be worn down and smoothed and polished. If presently the stone be arrested by some obstacle, and the ice flows over it, it will in some measure also rub down the rugosities of the upper surface, but probably not to the same extent. The stone will thus have two more or less parallel faces—one a good deal smoothed, and the other not quite so much—but the other angles or edges of the stone will remain intact, and unrounded and unsmoothed. We cannot understand how by any process a glacier can make a true boulder with subangular edges or a curved outline all round, or in the case of soft polygonal stones

polish and smooth the different facets as well as the angles. This rounding and smoothing and blunting of angles have always been attributed to water, and I take it that conclusion is generally held still.[1]

Now the remarkable part about the boulders in the surface beds of Eastern England, those of local origin as well as the foreigners, is that they are all either subangular or rounded. The true glacier type of skidded flat stone, I have never seen there, nor have I seen specimens of those enormous sharp-edged erratics which have never left the glacier's back until they were finally laid to rest. The only large blocks are the local ones, while the far-travelled foreigners are not only small in size, but greatly rounded and worn, while those which have travelled less have their angles still preserved, but they are blunted and rubbed down by rolling into subangular forms. This, so far as I know, is universal. How, then, can we attribute these boulders to ice-portage? If they had come on the back of the glacier they should be completely sharp and fresh, and we ought to have a great many of them of very large size indeed, especially the crystalline boulders. A mass of ice can carry a load as big as a house just as well as a pebble, but the crystalline boulders are nearly all small. It is only the local rocks that occur in fairly large masses. Nor, again, ought they (as they are) to be sorted roughly according to their size, so that we find them as a whole diminishing in size as we get away from their source. This is not the fashion with ice-portage at all, as a very casual visit to a living glacier and a living moraine will prove. There the biggest stones are often found in the most remote moraines, having travelled the furthest. But we are told these stones are sometimes scratched, and in the case of the soft stones not infrequently scratched, and that must surely be due to ice. So they are scratched. The absurdity to me is the conclusion that the majority of these scratches were made in any way by ice, or that ice could possibly have had a part in the work. Let us look a little more closely than is usually done by those who cling to ice, as a drowning man is said to cling to a straw, without ever considering its actual handiwork.

When ice first enters a valley with rough and torn edges to its rocks, it proceeds no doubt to rub these rough places down and to smooth them, and to remove the parts that cause friction until it creates for itself a smooth and polished bed as a river does. The result of this action is the pouring out at its foot of a considerable quantity of mealy water. This part of the work is, however, presently finished, and, except where the slope is great

[1 It is well to bear in mind the intimate connection between ice and water-action going on in a glacier. Thus, in summer the runlets of water, which form upon the surface of the ice, gradually form streams which fall down some crevasse through the ice to the bed of the glacier, and, acting with a gyratory motion upon the angular stones and gravel, may produce not only hollows in the floor of the glacier, but also rounded boulders, often of considerable size. These in time find their way down the ice-stream to the terminal moraine of the glacier. Thus it is often difficult to separate the action of ice from that of water in such cases.—Edit.]

and where the ice probably moves *en masse*, it ceases to denude altogether, having made for itself a virtually frictionless route to travel over, just as a river only denudes in its torrential parts. If an angular stone falls down a crevasse and reaches the bottom, and if being held by the ice it is pressed against the polished bed of the glacier, it will no doubt, if hard enough, score and scratch it with any of its projecting angles or edges, just as emery paper will scratch a piece of polished brass. How, on the other hand, the polished and smooth bed of the glacier is to scratch and score the loose stone in the ice—that is to say, how the polished brass plate is to scratch the emery paper—I do not see at all. It may rub off some of its projections, but how a smooth surface can scratch anything passes my comprehension. Occasionally two angular loose stones may press against each other under a glacier and scratch each other, but this must be a very unusual occurrence, and the best proof of it is what has been remarked over and over again, namely, the comparatively small number of scratched stones in true living moraines, the workshops which the glacial theorist carefully avoids. This is not all. The great majority of the stones from the Eastern Counties on which I have seen scratches are the native soft rocks. The number of hard crystalline boulders of foreign origin on which I have noticed scratches is very small indeed. In all cases the scratches have occurred on stones more or less rolled, and in the case of the polygonal chalk boulders not only on rolled boulders but on boulders with polished facets. These scratches were certainly made contemporaneously with or subsequently to the rolling which destroyed the angles and polished the surface of the stones. If so, how could ice be the agent which produced them. We cannot well postulate an ice-sheet in Norfolk and Suffolk dragging in to itself rounded and polished stones from the open waters of the North Sea, where the boulders were being rolled and smoothed in order to give them a few finishing touches. The process seems absurd. The fact is, these scratched stones have become a fetish. The glacialist naturally wants to find if he can a simple and ready test of the work of ice, and he has jumped at this particular test as a very convenient one, when as a matter of fact it is no test at all. He has followed a false scent in supposing that the scratches on loose stones have any analogy to the scorings and groovings on the smooth beds and side-walls of glaciers, which they have not. The very fact of there being a considerable number of scratched stones in a bed of clay or sand is a proof that that bed is unlike a moraine, and not that it is like it. The many bruised faces and black eyes which are to be seen in Clare Market are not, as some glacialists would argue, the results of the battle of Waterloo—where there were many wounds inflicted, but not many of that kind. To sum up this part of the case, there is no single feature known to me in the foreign boulders of Eastern England, any more than there is in the domestic and native ones, to justify us in attributing them to the handiwork of ice. They are simply a number of more or less waterworn boulders, such as occur

in mountain torrents where crystalline rocks abound, where some of the stones are completely rounded and others are blunted and subangular.

But we are asked, how can you account for their portage except by ice? What other force was capable of bringing them to where they are found from places so distant as Norway and Denmark? I reply that whatever force brought them it could not possibly have been ice, for several very potent reasons, to which we will now turn. The first reason is, that the foreign stones do not all come from the same direction; and as they are found in the same beds mixed together, it seems impossible to attribute them to the portage of ice, which moves along perfectly defined fixed lines of least resistance. Mr. Goodchild, it is true, fathered some years ago an extraordinary theory according to which there could be currents flowing athwart each other in a great mass of almost solid matter like ice. I do not know whether he still holds this view or not. To me it was, and it remains, incomprehensible. It is quite true that when a glacier is coming down a wide valley with a slight momentum, and is joined by a subsidiary glacier from an influent valley (which may be steeper), the intruding glacier, whose flow is more rapid, will thrust the other glacier back for a short space, and it will appear as if the ice were moving in two directions, and this will continue so till the two ice-streams have coalesced. But this, which is a perfectly simple and credible mechanical process, and only involves the adjustment of two rivers of ice with initially varying force and direction when accommodating themselves to a common path, is a very different matter to divergent currents *arising* or existing in ice-sheets and being continued in them when the ice is supposed to be moving across natural obstacles. Such a process, and the thrusting back of one glacier by another, is very different to currents of ice crossing each other in a great ice-mass. Such a process is to me incredible, nor have I been able to find any physicist to credit it. If we cannot appeal to divergent currents in the ice, how are we to explain the bringing together of stones from contrary directions to the same place by means of ice?

(*To be concluded in our next Number.*)

VII.—The Exfoliation of Gneiss in Brazil.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

PROFESSOR J. C. BRANNER has written a most interesting and valuable treatise on the "Decomposition of Rocks in Brazil," of which he has kindly sent me a copy.[1] All who want to study agencies of decomposition and denudation as they act in tropical countries cannot do better than read Professor Branner's clear and well-digested exposition, illustrated as it is by excellent reproductions of photographs and by figures and diagrams.

Among the many remarkable effects brought about by changes

[1] "Decomposition of Rocks in Brazil": Bulletin Geo. Soc. America, vol. vii, pp. 255–314, pls. x–xiv.

of temperature and decomposition in the gneissic rock-masses of Brazil, perhaps the most striking is the large scale on which exfoliation takes place, producing, in combination with other agencies and with structure, characteristic topographic rounded forms or bosses and conical peaks.

Among many illustrations Professor Branner mentions a rounded peak just east of the Corcovado, where the "surface has flaked off in great sheets that have slid down the mountain slopes." In the Gavêa (plate xii) these scales wrap round the peak, and it is remarked as a noteworthy feature in the exfoliation of peaks that "the flakes came to a feather edge on the downhill side so that they overlap each other like gigantic scales."

After referring these characteristic scalings to what is no doubt their true cause, expansion and contraction aided by decomposition along fractures, Professor Branner gives a table of the linear expansion of gneiss at several temperatures, taking one part in every 200,000 as its average expansion for one degree Fahrenheit, which shows that a rise of 103° would produce a lengthening of 1·854 inches, and 10° of 0·18 inch.

Evidence is brought to show that the maximum variation of temperature in Brazil is 100°, on which Professor Branner remarks: "It must be confessed that these figures are disappointing, for they lead one to suspect, if they do not show, that exfoliation, on account of changes of temperature and where small areas are exposed, is not so active an agency in Brazil as the exfoliated peaks and boulders constantly suggest."

One of my objects in calling geologists' attention to this excellent paper is to point out that the *cumulative* action of these recurrent expansions and contractions seems to have been lost sight of. So long ago as 1888 I gave instances in this Magazine[1] showing that the effect of ordinary daily alternations of temperature on terra-cotta copings set in cement was in time to produce permanent lengthening. I have been observing the phenomena in many examples since, and I pointed out some of these copings at Blundellands to Professor Lapworth and other geologists when on an excursion of the British Association at the Liverpool Meeting last year. I find that the lengthening proceeds very slowly from year to year, that it takes place in the summer, and to the greatest extent in the hottest weather, and not appreciably in the winter. I attribute it largely to the stresses set up by the greater expansion of the heated top surface over that of the under-surface. The natural tendency of this differential expansion is to hog up the coping, but this being resisted by its weight the underside is strained and lengthened, the forces being directed longitudinally, and the hogging up taking place at a fractured joint or at a ramp, if there be one, in the coping.

Few people, I fancy, have any conception of the enormous silent force which is developed by even a small rise of temperature. In the case of rolled iron Sir B. Baker estimates it as a stress of a ton

[1] "Effects of Alternations of Temperature on Terra Cotta Copings set in Cement," etc., pp. 26, 27.

per square inch for every 12° Fahrenheit. Though there are no data that I know of on which to estimate the stress set up in gneiss or terra-cotta by a given rise of temperature, we can see that it cannot be otherwise than severe.

This is the suggestion that I have to make:—The direct heat of the sun in Brazil must greatly exceed that in this country, and the range between the temperature of the gneissic rocks with the sun in the zenith and the temperature of the same during midnight radiation must be very considerable. Now, according to my studies, this is the very thing wanted to produce disruption. The surface of the gneissic rock becomes greatly heated during the day, but this daily range of temperature cannot extend far into the rock (unfortunately I know of no experiments to determine the depth); consequently the difference of expansion between the upper and under layers creates shearing stresses, which, being renewed daily year after year, eventually shears the rock, quarrying out a bed or sheet of a thickness determined by several factors, in the same way that the cement bed of a terra-cotta coping by recurrent daily expansion of the coping is sheared along its whole length. Once the minutest fracture occurs, water and chemical agents, as so well set forth by Professor Branner, detach the large sheet or scale from its parent rock.

Shortly stated this appears to me to be the origin of these huge exfoliated scales and the "sheets of rock, sometimes 15 feet thick," "utilized by the quarry-men in breaking out blocks of convenient sizes," but which "sheets are more commonly from 2 to 10 feet thick," and "often as thin as a knife-blade."

It is the recurrent stresses that eventually break up the rock, for on each expansion the rock is strained, and it does not recover its exact original condition on contraction. As field-geologists, we all know that an obdurate rock may resist one great blow of a hammer, but yields to repeated lesser blows; and it is this daily and yearly recurrent straining of the gneissic rocks of Brazil that in my opinion finally shears off large plates, and produces the topographic features so characteristic of that country.

VIII.—The Range of Species in the Carboniferous Limestone of North Wales.[1]

By G. H. Morton, F.G.S.

ATTENTION having recently been directed to this subject, I have been induced to present the results of many years' collecting in the Carboniferous Limestone of North Wales. The formation there presents four well-defined subdivisions, each of them, with the exception of the highest, having distinct lithological characters, viz.: Lower Brown Limestone, Middle White Limestone, Upper Grey Limestone, and the Upper Black Limestone. Lists of the fossils have been made, collected more or less continuously along the country from each subdivision.

[1] Read before the British Association, Section C, Liverpool, 1896.

In North Wales the occurrence and succession of the species in the subdivisions vary in different areas, and the larger the area examined the more difficult it becomes to find species peculiar to certain horizons. In order to obtain a definite result I have compiled three separate lists of the species obtained in that number of distinct areas. There are the Llangollen, the Flintshire, and the Vale of Clwyd Lists. Each of the lists shows the relative scarcity and abundance, and the range of the species in the subdivisions; and although future search will doubtless add to the rare and occasional species, the number and range of the common and very common must be very nearly correct. Neither the rare nor the occasional species are of much use in defining distinct horizons in consequence of their rarity, and it is only the common and very common species that can be expected to indicate a definite horizon or zone. In North Wales a great difficulty arises from the occurrence of all the common and very common species in the Upper Grey Limestone, with the exception of *Productus comoides*, and although all pass downwards, they become scarce in consequence of the general paucity of fossils in the inferior subdivisions.

In the Llangollen List there are 69 rare, 28 occasional, 16 common, and 27 very common species. Deducting Foraminifera, which are not in the other lists, there are 36 species that are common and very common, and they all occur in the Upper Grey Limestone, with the exception of *Posidonomya Gibsoni* from higher strata, and *Productus comoides* in the Lower Brown Limestone, all the other species in the list being rare and occasional forms.

In the Flintshire List there are 92 rare, 35 occasional, 30 common, and 11 very common species; and of the 41 common and very common, 37 species occur in the Upper Grey Limestone, 3 of the remaining species, *Posidonomya Becheri*, *Aviculopecten granosus*, and *A. papyraceus*, occurring in the Upper Black Limestone, and *Productus comoides* in the Lower Brown Limestone.

In the Vale of Clwyd List, which includes the Great Orme's Head, there are 16 rare, 22 occasional, 12 common, and 10 very common species; and of the 22 common and very common, 21 species occur in the Upper Grey Limestone, the exceptional species being *Productus comoides*. None of the 21 species are peculiar to the subdivision, for they all occur in the underlying Middle White Limestone. The number in the list is less than in the others, on account of the Upper Grey Limestone having been considerably denuded in the Vale of Clwyd.

Nearly the whole of the common and very common fossils occur in each of the three lists, for there are few that are not found in all the areas.

Of the numerous common and very common species found in the Carboniferous Limestone of North Wales, it is impossible to find any that are restricted to horizons of less importance than the subdivisions into which the formation is naturally divided. An examination of the first appearance and continuity of the species seems to indicate that they were introduced from some pre-existing

area, and that the upper beds of the formation are more recent than in Derbyshire and Yorkshire, where the thickness of the Limestone is very much greater.

The sudden appearance of species in restricted areas, like those found in the Upper Grey Limestone at Axton, in Flintshire, where 20 species occur, and at Graig-fawr, in the Middle White Limestone, where six species occur, not found elsewhere in North Wales; and the early appearance of three species in beds of Black Limestone and shale at the base of the Middle White Limestone at the Great Orme's Head, seem to indicate migration from some other area. The latter species are *Orthis Michelina*, *Spirifera humerosa*, and *S. rotundata*. *Spirifera humerosa* had only been previously found at Llangollen and in Flintshire, while *S. rotundata* was rare in North Wales; but none of the three species had been previously found at a lower horizon than the Upper Grey Limestone. *Productus giganteus* first appears in the Lower Brown Limestone, and very large specimens occur within 50 feet from the base at Moel Hiraddug, a few miles from Rhyl. The species occurs all through the Carboniferous Limestone, and thousands may be seen in the Upper Grey Limestone.

In this paper the range of the species found is confined to North Wales, but when the subdivisions of the Carboniferous Limestone in other parts of the country are worked out, and the species from each tabulated, it will be interesting to compare the result with that obtained in North Wales.

REVIEWS.

I.—Publications of the Palæontographical Society. Vol. L, 1896.

THE fiftieth issue of this well-known Society maintains the high character of the previous annual volumes, and augurs well for the future prosperity of this useful body. The volume contains, in addition to the usual catalogue of memoirs already published, and other matter of general interest, an extract from the Report of the Council to the Annual General Meeting held on June 19, 1896. This Report was noticed by us in the Geological Magazine for September last (Dec. IV, Vol. III, 1896, pp. 385–388, Pl. XIII); we only call attention to it here in order to reproduce the portrait of another of the founders of the Society therein referred to, namely, Dr. J. Scott Bowerbank, F.R.S., F.G.S., who was Secretary from May, 1847, to 1862, and President from 1865 to 1876.

Like most of its predecessors the volume is a composite production, containing—

1. *Part III* of "The Crag Foraminifera," by Professor T. Rupert Jones, F.R.S., F.G.S.; assisted by Messrs. H. W. Burrows, C. D. Sherborn, F. W. Millett, R. Holland, and F. Chapman. (pp. 211–314 and pls. ix–xii; the plates do not accompany this part of the text.)

2. "British Jurassic Gasteropoda," Part I, No. 9, Gasteropoda of the Inferior Oolite (pp. 445–514, pls. xli–xliv), by Wilfrid H. Hudleston, M.A., F.R.S., V.P. Pal. Soc. (Completed with title-page and index.)

3. "A Monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*," by Wheelton Hind, M.D., B.Sc. Lond., F.G.S., etc. (Part III, pp. 171–182, pl. xxi; completed with appendix and index.)

4. "A Monograph of the British Carboniferous Lamellibranchiata," by Wheelton Hind, M.D., B.Sc. Lond., F.G.S. (Part I, Mytilidæ, pp. 1–80, pls. i, ii.)

5. "A Monograph of the Devonian Fauna of the South of England," by G. F. Whidborne, M.A., F.G.S. (Vol. III, Part I, Fauna of the Marwood and Pilton Beds of North Devon and Somerset, pp. 1–112, pls. i–xvi.)

1. The Crag Foraminifera, Part I, was commenced in 1865 by Prof. T. Rupert Jones, F.R.S., assisted by W. K. Parker and H. B. Brady (pp. 1–72). One page (p. 73), which completes this part, was issued in 1895 with Part II. The second part was begun in 1895, with five new assistant authors, as stated above—the two early colleagues who shared in the labour of Part I having in the intervening thirty years both passed away, leaving Professor Rupert Jones to seek new assistants. These he has fortunately found in increasing numbers, so that the work might now be known as the "*hexade*" or the "*hexameron*"; and if each of the six authors contributes his quota, the work should proceed "merrily as a marriage peal."

Plates i–iv appeared with the text to Part I in the 1865 volume, and plates v–vii with the text to Part II in 1895, so that the statement on p. x in Part III, 1896—"list of genera and species described and *figured* in Part III"—is hardly correct, seeing that no plates accompany Part III.

We venture to urge upon authors the desirability of making parts of monographs complete in themselves, especially when, as so often must happen, there comes a hiatus of years between the issue of parts of a monograph.

In Parts II and III of this monograph on the Crag Foraminifera, the authors give not only careful descriptions of a large number of species, but Mr. Burrows has added an interesting chapter "On the Stratigraphy of the Crag, and notes on the Distribution of the Foraminifera," which must prove of great value to geologists. The synonymy has been dealt with by Mr. Sherborn, and we see the terrible consequences arising from the want of his "*Nomenclator Zoologicus et Palæontologicus*" to refer to at any moment, in the long lists of synonyms which fill pages of text in such forms as *Truncatulina lobatula, T. variabilis, T. Haidingeri,* and *T. Ungeriana*; or in *Globigerina bulloides, Planorbulina Mediterranensis, Polymorphina communis, Textilaria sagittula, T. agglutinans,* etc. Every palæontologist must feel grateful to the authors for their excellent work, leading the way to a better knowledge of the forms of these micro-organisms of our English Crag.

2. The British Jurassic Gasteropoda, by Wilfrid H. Hudleston, M.A., F.R.S., etc. The completion of this task, which has occupied ten years in its publication, to say nothing of previous study, must be a source of satisfaction to the author as well as to palæontologists, field-geologists, and collectors of fossils.

That the Gasteropoda of one formation, the Inferior Oolite, should occupy a volume comprising nine parts, 44 plates, and 514 pages, is a sufficient evidence of the growth of palæontological knowledge. Morris, in the second edition of his famous Catalogue, recorded sixty species; the present census enumerates 398 species and 40 varieties from the Inferior Oolite.

In these days of excessive species-making and of the consequent obliteration of old landmarks, it is satisfactory to find that the author adopts a plan of judicious moderation both as regards species

and genera. He remarks that "when once the doctrine of Evolution is admitted in its entirety, the ideas attaching to such expressions as 'genus' and 'species' lose somewhat of their definition. Nevertheless, they are necessities in classification; and even if they do not absolutely exist in nature, it becomes necessary as by a sort of legal fiction to presume that they do exist for purposes of scientific arrangement."

The author speaks favourably of the trinomial system, but considers it would be unwise at present to depart from the old course, not, however, because the binomial system was the more philosophic or the better. "We must jog on as well as we can with the help of sub-genera and var. *a* and var. *b*, and this no doubt can be done without any difficulty." In this way the number of species is kept down, and the subject remains free from that complexity which must attend an undue multiplication of names. Even sub-genera, when introduced, are rightly kept within parentheses, as in the case of *Nerinæa* (*Nerinella*) *gracilis*, *Nerinæa* (*Ptygmatis*) *pisolitica*, *Turritella* (*Mathilda*) *opalina*, etc. The author further observes with regard to the classification of the fossil Gasteropods, that the subject must be treated from a conchological point of view: "we must fall back upon the shell as the basis of classification of our fossils, and accept such aid from zoology as is consistent with the material at our disposal."

With regard to palæontological horizons, the author remarks that "From their uncertain and unequal distribution, and also from the fact that Gasteropoda have been greatly influenced by the physical conditions that obtained during the period of deposition, it is probable that they are of less value as indicators of horizons than the Cephalopoda, the Ammonites especially. Moreover, with the exception of one or two groups, such as *Nerinæa*, their mutations have been much less rapid, so that forms have been more enduring, and thus sundry demoid common types may be said to pervade nearly all the beds."

The author proceeds to give us an excellent account of the stratigraphical features of the Inferior Oolite in its range from Dorsetshire to Yorkshire. He has himself studied the rocks and their fossils at most of the important localities, and has, moreover, employed a fossil-collector to make diligent search, so that he has accurate knowledge of the horizons of nearly all the species that have come under his notice.

The Inferior Oolite is divided into two broad divisions as follows:—

	Zones.
Upper Division	*Ammonites Parkinsoni.*
	,, *Humphriesianus.*
Lower Division	,, *concavus* (subzone).
	,, *Murchisonæ.*
	,, *opalinus.*

Other local zones and fossil-beds are duly indicated in the detailed accounts of various sections, so that this introductory essay on

stratigraphy is full of interest and value to the student of Jurassic geology. At the commencement of the work the author adopted the term "*Sowerbyi*-subzone" for the highest bed of the Lower Division, though not without protest. Subsequently he realized that this important life-horizon should bear the name of its most characteristic Ammonite, *A. concavus*. The *Sauzei*-bed, which is much more nearly on the *Sowerbyi*-horizon, forms the base of the Upper Division, and is included broadly in the *Humphriesianus*-zone.

Among the species described are two fresh-water forms—*Paludina Langtonensis* and *Valvata comes*: these come from a "mortar-like deposit," apparently the ancient decomposed surface of the Chipping Norton Limestone. Associated with them there is "apparently a Bathonian fauna," so that the evidence tends to show that these fresh-water forms may belong to the (local) base of the Great Oolite Series.

In a footnote (on p. 492), the author describes a new genus from the junction-bed of the Middle and Upper Lias at Thorncombe, Dorset, naming it *Wilsonia Liassica*, in honour of Mr. E. Wilson. The species is figured on plate xliv.

3. Dr. Wheelton Hind's monograph on *Carbonicola*, *Anthracomya*, and *Naiadites* (Part III) is brought to a termination, and completed with one plate, an appendix, and index.

4. Dr. Wheelton Hind commences a fresh monograph on the British Carboniferous *Lamellibranchiata*: why this new departure? Could not the earlier described forms have been included in the later and more embracing title? The plates by Mr. A. R. Searle are admirable. The author deals in his Introduction with the horizons in the Coal-measures in which molluscan fossils occur; he then gives a bibliographical sketch of the works which have been already published dealing with the fossils of this formation; commencing with the Rev. David Ure's classic work "The Natural History of Rutherglen" (1793); and adding descriptions of the species of *Modiola* and *Lithodomus*. We shall notice Dr. Wheelton Hind's work again later on.

5. The Rev. G. F. Whidborne continues his monograph on the Devonian Fauna, taking up in this volume the Fauna of the Marwood and Pilton Beds of N. Devon and Somerset. The author deals with fish-remains in the form of scales of *Holoptychius* from Ashford; a new Myriopod named *Cariderpestes gyius*, an obscure form, possibly part of a *Euphoberia*? but difficult to determine. We have also Phyllocarids; a supposed cirripede (*Anatifopsis*); three Trilobites (*Brachymetopus*, *Phacops*, and *Phillipsia*); numerous Ostracods; and many Mollusca; carefully illustrated in sixteen plates. We cannot but admire Mr. Whidborne's industry and energy in working out, both in the field and in the study, the fauna of his own Devonian formation, and making so many fossils known, by means of figures and descriptions, from these ancient rocks.

II.—Faunas of the *Paradoxides* Beds in Eastern North America. No. 1. By G. F. Matthew.[1]

IN this article, which deals with the smaller crustaceans, including the genera *Agnostus* and *Microdiscus*, there is a definite attempt to correlate the several subfaunas of *Paradoxides* which occur in America with those found in Europe. Of the six subzones into which the *Paradoxides* beds of Sweden have been divided, the above author recognizes four as existent in America. Of these the second has been recognized by its fauna in New Brunswick, Newfoundland, and Massachusetts; the first has been found only in the province first-named, and the fourth in Newfoundland.

Some facts relative to the development of the larval forms of *Agnostus* and *Microdiscus* are given, which indicate a nearer relationship between these genera than is apparent from the adult individuals. The pygidium in *Agnostus*, as shown from the larvæ, had three stages of growth; the earliest marked by the posterior, obscure somites of the posterior lobe of the rachis, the second by the two anterior somites of the same lobe, and the third by the two anterior lobes of that rachis. In the head-shield the occipital ring is usually quite aborted and the true posterior lobe largely suppressed; the so-called posterior lobe is thus a fusion of the middle lobes of the glabella. The anterior lobe becomes more definite and prominent than in most trilobites.

A new species of *Microdiscus* of the *Olenellus* fauna is described, differing in its short glabella (and cephalic shield) from the other *Microdisci* of that fauna; attention is called to the resemblance of its head-shield to that of the forms with long occipital spines that are prevalent in the *Paradoxides* beds, and the suggestion is offered that it may be of the same stock as that from which they are descended. The *Microdisci* of the *Olenellus* and *Paradoxides* beds are classified in this article and divided into subgenera, their relation to each other being shown by an analytical table, descriptive of the various parts of the head-shield and pygidium. *Stenotheca* of Salter is claimed to be crustacean, and *Plumulites* of Barrande is said to occur in the *Paradoxides* beds of Newfoundland. Four plates, with full descriptions of the figures, accompany the article.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 20, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Glacial Phenomena of Palæozoic Age in the Varanger Fiord." By Aubrey Strahan, Esq., M.A., F.G.S.

The Gaisa beds of the Varanger Fiord consist of slightly altered quartz-grits, with red sandstones and shales, and rest upon a deeply denuded surface of the metamorphic rocks. In a section, first noticed

[1] Trans. New York Acad. Sci., vol. xv, sig. 12, August 3, 1896.

by Dr. Reusch, a heterogeneous mixture of grit and clay with boulders of granitic and other rocks is seen to be intercalated between the quartz-grits, the bedding of the overlying grit proving that this boulder-rock was contemporaneously formed, and not subsequently wedged in. The surface of the grit below the rock is characteristically glaciated. Proof is given that the striated surface is not the floor of a thrust-plane, and that the boulder-rock is not a fault-breccia or a crush-conglomerate, but a "till." In the absence of fossils the Gaisa formation is doubtfully assigned to an early Palæozoic age. It exhibits the same sedimentary characters as the rocks of later date in other parts of the world in which glacial phenomena have been observed. The glacial episode is attributed to a temporary change of climate rather than to the high latitude in which the section lies.

2. "The Raised Beaches and Glacial Deposits of the Varanger Fiord." By Aubrey Strahan, Esq., M.A., F.G.S.

The Raised Beaches range up to nearly 300 feet above the sea. Though a number of impersistent shingle-banks occur at various heights, the highest is constant, and can be traced along the same level either as a shingly terrace or by a zone of wave-worn rocks. Evidence is furnished by the relative size of different parts of the beach that the prevalent wave-action was from the west, and by the greater abundance of erratics on or below the beach than above it, that floating ice was at work.

At the head of the fiord a blue clay dotted over with stones is now being formed, and the raised beach there consists of a similar material. Both here and elsewhere this clay simulates a Boulder-clay; but for reasons given it is believed to be a marine fiord-deposit, into which many stones have been dropped by floating ice.

Deposits of true glacial age, in the form of mounds of gravel, are described, and shown to have yielded the material out of which parts of the Raised Beaches are formed. The glaciation of the fiord is attributed to floating ice, and is shown to have taken place before the formation of the Raised Beaches, at a time when the sea surrounded this part of Finmark, by way of the Varanger Fiord, the Tana Valley, and the Tana Fiord.

II.—February 3, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "The Subgenera *Petalograptus* and *Cephalograptus*." By Miss G. L. Elles. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

The forms referred to in the paper are accepted as subgenera of *Diplograptus*, as defined by Lapworth. The two subgenera have frequently been much confused, but examination of specimens preserved in relief shows that they have very distinctive characters, especially at the proximal ends. The author gives diagnoses of the two subgenera, and detailed descriptions of the following forms:—

Petalograptus folium, His.; *P. palmeus*, Barr., and varieties *latus*, Barr., *tenuis*, Barr., *ovato-elongatus*, Kurck; *P. ovatus*, Barr.; *P.*, n.sp.; *Cephalograptus cometa*, Gein.; and *C.*, n.sp.

She concludes that *Petalograptus* has been derived from *Orthograptus foliaceus*, *O. truncatus* having been a step on the way. The latter form has an almost horizontal connecting-canal, so that the first of the second series of hydrothecæ arises at nearly the same level as the first of the primordial series; whilst, if the connecting-canal became more oblique and the thecæ more concavely curved, a form identical with *P. palmeus* would be the result. Further changes would give rise to *P.*, n.sp., and subsequently to *P. folium*. When the first theca of the second series arises so late that the sicula is entirely free on the side remote from that on which the first of the primordial series arises, an important stage is reached, and the form becomes a *Cephalograptus*. Such a form is furnished by *C.*, n.sp., which is in some respects intermediate between *Petalograptus* and *Cephalograptus*. The extreme form is reached in *C. cometa*, in which the first hydrotheca of the second series is still later; the hydrothecæ are still longer than those of earlier forms and almost parallel to the long axis of the rhabdosoma. The other known forms of *Petalograptus* may have been derived from *P. palmeus*.

It seems exceedingly likely that the *Petalograpti* had a *Phyllograptus* as a remote ancestor, but the evidence for this is not yet complete, nor can the author state whether *Cephalograptus* had a further stage in the form of *Dimorphograptus*.

2. "On some Superficial Deposits in Cutch." By the Rev. J. F. Blake, M.A., F.G.S.

The author arranges the deposits of which he treats under the following heads: (1) Subrecent Concrete; (2) Boulder Beds associated with the former; (3) Quartzite Reefs; (4) Infratrappean Grits; (5) Laterite; (6) Alluvium and Rănn.

(1) The Subrecent Concrete consists of a calcareous, porous, laminated sand with milioline remains, which extends to a height of about 700 feet above the Rănn, and has a discontinuous distribution. The author gives reasons for regarding this as an æolian deposit, partly derived from recent marine accumulation and blown inland and uphill by the prevalent winds.

(2) The Boulder Beds are next described, their distribution noted, and their occurrence with æolian deposits recorded. The author argues that the æolian deposits once had a greater slope, and acted as carriers, so that, under the influence of rain, the stones from the hills slipped to their present position.

(3) The Quartzite Reefs are described as filling up cracks; the material is of æolian origin and derived from the surrounding rocks, and owing to this material having been formerly at a lower level than the latter, water stood on it for a sufficiently long time to permit of the materials being cemented by a siliceous deposit, and converted into quartzite.

(4) The Infratrappean Grits are maintained to be superficial deposits on the pre-trappean land-surface, some being the ordinary results of weathering, others due to the washing down of débris to a water-covered level, and others again simply æolian drift. It is thus seen that there has been constancy in the meteorological conditions of Cutch from recent times as far back as the Cretaceous period.

(5) The Laterite-deposits of the district occur to a height of only 120 feet above the Rănn. There is evidence that they were laid down in water at a time when the surface of the country was not very different from the present one. The material may have been partly derived from Jurassic rocks, but some of the constituents, as the eroded agates, must have come from the trap-rocks.

(6) The Rănn is an area which has recently been abandoned by the sea, owing to unequal movements, but there is evidence that deposit has also taken place in it, and the depression has become shallower, so that in course of time the whole surface will be made of alluvial or æolian soil.

III.—February 24, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Nature and Origin of the Rauenthal Serpentine." By Miss Catherine A. Raisin. B.Sc. (Communicated by Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.)

This serpentine has been already described by Herr Weigand as one of those which occur in regions of gneiss or schist related in their origin to those rocks. In order to test this hypothesis as to the formation of the serpentine, the author has examined the district, and has studied its rocks with the microscope.

Herr Weigand asserted that transitions could be recognized from typical gneiss to a peculiar amphibolite, and that the latter rock has been changed to serpentine. The author could find in the field no evidence of a passage from gneiss to amphibolite, and calls attention to the general difficulty of the supposition. She states that when the serpentine is examined microscopically, the greater part shows the usual appearance of serpentine derived from olivine, and can be distinguished from included parts, which have resulted from change in hornblende or other pyroxenic constituents. Further, that several accessory minerals occur which are usually found in peridotites. The rock also contains a peculiar chlorite. This she thinks the result of the modification of a biotite, for the latter mineral occasionally occurs as a constituent in a neighbouring serpentine, and both there and in the Rauenthal, intermediate forms apparently can be detected. It seems to her that the chemical analyses already published are not in harmony with the supposed change of a hornblende rock into serpentine.

While it is true that a hand-specimen sometimes shows a transition (generally rapid) from a rock consisting mainly of hornblende to

one which has consisted mainly of olivine, she maintains that this appearance is far more consonant with partial differentiation of the original magma, followed by fluxional movements and flow-brecciation. It is not that a mass of amphibolite passes into one of serpentine, but that a specimen of the latter is occasionally streaked by the former.

By comparison with other serpentines of the Vosges and elsewhere, which are admittedly developed from olivine rocks, so much likeness is found between them and the Rauenthal mass, that the origin must be similar.

2. "On two Boulders of Granite from the Middle Chalk of Betchworth (Surrey)." By W. P. D. Stebbing, Esq., F.G.S.

The author notices cases of occurrence of boulders in Chalk which have been previously described; and records the occurrence of two boulders which were obtained from the Chalk of the zone of *Terebratulina gracilis*. The larger weighed 7 lb. 7 oz., and measured $5''{\cdot}8 \times 6''{\cdot}25 \times 4''{\cdot}125$, and consisted of decomposed granite; valves of *Spondylus latus* and *Serpula* were still attached. The other, also granite, though of a different character, weighed 3 lb. 12 oz., and measured $3''{\cdot}6 \times 5''{\cdot}8 \times 4''{\cdot}5$. Professor Bonney has furnished a description of the microscopic characters of the two boulders, which are possibly of Scandinavian origin. The author discusses the mode of transport to their present position, and favours the agency of floating ice.

3. "Coal: a new Explanation of its Formation; or the Phenomena of a New Fossil Plant considered with reference to the Origin, Composition, and Formation of Coal-beds." By W. S. Gresley, Esq., F.G.S.

The author argues that the brilliant black laminæ in coal and similar materials to those which form these laminæ, which are found in earthy coals, shales, and clays, point to the former existence of an aquatic plant, having the general shape of the modern *Platycerium alcicorne*, which grew *in sitû*. He believes that much coal was formed by this aquatic "coal-plant," which grew amongst the mechanical sediments and the débris of the terrestrial vegetation which accumulated on the floors of sheets of water.

CORRESPONDENCE.

THE GREAT SUBMERGENCE "AGAIN."

Sir,—Has Mr. Dugald Bell adopted this title to show his surprise that the so-called "Submerger" has not been extinguished by his numerous writings on the subject?

Unless I have completely misunderstood the tenour of these communications, Mr. Bell formerly attached great importance to the supposed absence of high-level shelly Boulder-clay in the South of Scotland, as favouring his view that the Drift was due to *land-ice*: hence his strenuous endeavours to prove that such shelly beds did not

exist. These endeavours have proved futile, for, while a Committee, after sinking a well or enlarging an old one—I forget which—at Chapelhall, near Airdrie, have been enabled to say that they found no shells in the Drift where a previous observer had reported their presence, other observers have been discovering in Ayrshire large deposits of Boulder-clay in which shells occur, often even possessing their epidermis. What adds pungency to the fact is, that these large beds of Boulder-clay are exposed in numerous natural sections that were open to the eyes of glacialists and others interested, who failed to see that they contained marine shells—being perhaps stricken with an ice-sheet blindness—while time and money were being consumed in sinking wells elsewhere and finding nothing.

Now that large deposits of shelly Boulder-clay have been found to exist in Ayrshire at various heights, from sea-level up to 1062 feet, my friend Mr. Bell is not inclined to attach so much importance to their presence. In fact, he says, "the value of the Ayrshire sections as proofs of submergence has yet to be determined. My own opinion, frankly, is that it is *nil*."

As regards the suggestion that the Muirkirk beds have been laid down by a Frith of Clyde glacier, I can only point out that the hypothetical course of such a glacier does not correspond with that of any map I have yet seen which professes to give the lines of glacial flow in Scotland. It is really too bad to ask geologists to grant phenomena as due to the devious courses of masses of land-ice when such hypothetical courses have to be amended from day to day to fit in with the progress of discovery, and often involve the most surprising contradictions. T. Mellard Reade.

Park Corner, Blundellands,
February 3, 1897.

GENERAL SEQUENCE OF THE CARBONIFEROUS ROCKS.

Sir,—I feel deeply obliged to Mr. Etheridge for calling attention to an omission in the Introduction to my Monograph on the British Carboniferous lamellibranchs. I am sorry to say that in my table of the general sequence of Scottish Carboniferous rocks, the upper and middle groups of the Carboniferous Limestone series are also missing. How these lapses have come about I am unable to say, for I have the most distinct recollection of inserting these groups in their correct position in my MSS. Of course I am convicted of great carelessness in the reading of the proof, for which there is no excuse. Wheelton Hind.

OBITUARY.

We regret to announce the deaths of Dr. Bernhard Lundgren, Professor of Geology in the University of Lund; and of Professor Constantin Baron von Ettingshausen, the distinguished Palæobotanist of Graz, Austria. We hope to give some account of these eminent men in the next number of the Magazine.